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ABSTRACT

This regional trade union seminar was attended by representatives from Belgium, Germany, the Netherlands, Sweden, Switzerland and the United Kingdom. The purpose was to consider the job profiles and tasks in the machine tools and automobile industry in 1980, and to consider the vocational and general education needs of young people to help them meet the demands of jobs and society at that time. Preliminary reports prepared for the seminar included: (1) "Technical and Managerial Innovations Present and Prospective for the Machine Tool Industry, for the Automobile Industry and for Both Industries," (2) "Changing Work Duties in the Machine Tool and Automobile Industries," (3) "Prospective Job Profiles in the Machine Tool and Automobile Industries," (4) "General Educational Needs for the Future," (5) "Vocational Education and Training for the Future," and (6) "Vocational Retraining in the Future." (GEB)

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INTERNATIONAL SEMINARS 1968-1

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EDUCATION AND TRAINING FOR THE METAL WORKER OF 1980

REGIONAL TRADE UNION SEMINAR

Paris, 8th-11th October, 1968

FINAL REPORT

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Introduction

The regional trade union seminar on Education and Training for the Metal Worker of 1980 was organised by O.E.C.D., at the request of the Trade Union Advisory Committee, as part of its Programme of Activities for Employers and Workers. The subject chosen was considered as a follow-up to the International Conferences on Manpower Aspects of Automation and Technical Change (Zurich, February 1966) and Methods of Adjustment of Workers to Technical Change at Plant Level (Amsterdam, November, 1966).

The seminar, which was attended by trade union representatives from Belgium, Germany, the Netherlands, Sweden, Switzerland and the United Kingdom, was held in Paris from 8th-11th October, 1968. Its purpose was firstly to consider what would be the tasks and the job profiles in the Metal Industry in 1980, particularly in two branches, machine tools and the automobile industry, as a result of the production processes and management methods which would be in use at that time; and secondly, to consider what sort of vocational and general education would be needed by young people now entering school, to meet the demands of these jobs and of society in 1980.

The final report on the seminar, issued in one volume only, contains a summary of the discussion by Joseph Moon, Principal Training Officer, Engineering Industry Training Board, United Kingdom, the full text of the reports prepared for the seminar by the rapporteurs, and the statements by the employers' representative Mr. E. Boursier, and the T.U.A.C. representative Mr. Charles Ford. A list of those taking part in the seminar is also included.

SUMMARY OF THE DISCUSSION

by Joseph MOON
Principal Training Officer,
Engineering Industry Training Board,
United Kingdom.

> "When planning for a year - sow corn. When planning for a decade - plant trees. When planning for life - train and educate men."
>
> Kuan Tsu 3C. B.C.

This conference on education and training for the metal worker in 1980 can be seen as part of the series to consider technical change, and the interdependence of technical innovation and the development of people. An earlier O.E.C.D. conference stated "the common view is that technical change offers the potentials for a better life, but the benefits have to be enjoyed and the costs have to be minimized if the ultimate goals are to be realized". One ought to be concerned with managing the changes so that the optimum benefits for the individual and society can be obtained. Education and training clearly have important parts to play in this.

The conference concentrated its attention on four main areas:

- Production Processes and Management Methods.
- Future Work Duties and Job Profiles.
- General and Vocational Education.
- New Training Systems and Methods.

which were considered in the context of the automobile and machine tool industries. These were chosen because of their central importance to industry. They also appear to show the diversity of the manufacturing situation. The automobile industry is based on mass production techniques whilst the machine tool industry is related to other technical developments and reflects requirements found in all sizes of batch manufacture.

Machine Tool Industry

The machine tool industry in Europe tends to be centred in medium and smaller size firms, which provide mainly specialized equipment. The same situation exists in the United States.

It seems that this size of firm may remain in the machine tool industry. Speakers emphasized that it was impossible to obtain any reliable forecast of trends of output by the simple extrapolation of economic trends and this view was widely shared by all present. The most significant organisational and technical trends lie in the application of numerically controlled machine tools. These are now being used in the smaller firms, as they may give greater flexibility to production loading even in smaller batch manufacture. They are no longer regarded as equipment suited solely for larger firms.

As data processing gains wider acceptance in companies, organisational requirements may well have a bigger effect on manpower requirements than technological innovation. Moves toward complete integration of manufacturing processes and control may take eight to ten years to achieve from the point of inception, but it is possible however to develop such systems in stages. Computer controlled systems are already being developed now in which every aspect of the manufacturing process has been studied in great detail and procedures developed to handle minor variations. These cover requirements from the initial demand in materials preparation, work loading, tooling requirements, automatic transfer of materials and pallets, automatic operation of machine tools, cutter changes, swarf removal, re-setting of workpieces and the loading and unloading of finished work. Such computer controlled systems apply not only to mass production, but also to batch production (Williams of the Molins Machine Co. Ltd. of Great Britain, has pointed out that the level of capital investment needed to make the enormous savings in running costs his company made by computer controlled manufacture, is little more than the investment required for a manual facility. "In fact when buildings and ancillary services connected with large numbers of people are taken into account, the investment for a given level of output will be lower for Computer SYSTEM 24 than for a conventional plant, even with double shift operation.")

Such integrated design and manufacturing systems underline the need to undertake much more careful manpower budgeting and training within companies, resulting in most cases in a need to increase the number of technicians and sometimes to a reduction of craft skills.

What emerged clearly from overall discussion was that there will be a training requirement affecting nearly all employees, which must start from the top and reach down throughout an organisation when integrated manufacturing systems are to be introduced.

Professor Simon explained one method currently being investigated at Berlin Technical University to measure the technical, economic and sociological factors involved in introducing such systems, and the general approach is described in his paper. It was hoped to provide more accurate forecasting techniques based on these studies.

Delegates were interested in a comparison of manufacturing trends especially within Comecon countries. Professor Simon pointed out the tendency towards rationalization and standardisation of machine tool manufacture within Eastern Europe due to the type of regime. Concentration within the machine tool industry was also occurring within the United Kingdom although this was imposed largely by the industry itself.

Considerable doubts were expressed about the usefulness or accuracy of quantitative manpower forecasting when membership of economic groupings and developments concerning a technological community were uncertain. Professor Simon felt that one could deal with this in mathematical terms by expressing the limits within which the model had been developed for varying conditions. He suggested also that the United States would probably become much more export minded in future. At the same time, Comecon countries might attempt to "dump" machine tool surpluses when the basic needs of the Eastern European market had been met.

In considering national and international trends it was interesting also for the delegates to note the growing number of small firms in both the United States and Germany using numerically controlled machine tools. It was emphasized that such equipment was not necessarily found only in large companies, nor was it peculiar to the requirements of larger companies.

Automobile Industry

The automobile industry is of special interest because of its dependence on mass production techniques related to a large consumer market. However, it is doubtful if the general distinction drawn in the conference between the automobile industry or machine tool industry and engineering is really a tenable one. Batch size of manufacture is only one consideration in the production process and other factors may prove more important and have greater effects on change of work pattern for the future metal worker. One of the more obvious factors is the introduction of new materials. A plastic gearbox housing for motor cars has already been successfully produced and used in an experimental vehicle and it is certain that many components which today are still manufactured from metal will certainly be made from synthetic materials in the future.

Major changes are also likely to take place to substitute the generally wasteful processes of metal cutting in favour of other processes such as metal forming, powder metallurgy, plastic deformation of solid raw materials, high energy rate forming, electron beam machining, electro-mechanical and electro-chemical machining. The likely result of these process changes will be a lesser emphasis on manual skills, with a correspondingly increased emphasis on knowledge and judgement required by employees.

Coupled with process change, is the potential for increased accuracy of manufacture. Professor Koenigsberger made the interesting observation "it is possible to improve the accuracy to which the machine tool can produce its pieces without increasing the accuracy with which the machine itself has been manufactured".

The concept of modular machine tools permitting the assembly of functional process units into various arrangements will clearly call for a different pattern of skill and knowledge requirements - on the whole for multi-skilled employees.

However, the biggest change which is likely to take place in the industry, lies in the distinct probability of developing integrated manufacturing systems. Computers will play a significant role in these being used both in the design and planning stages and throughout all the production phases of quality, process and production control.

Little doubt was felt by conference members about the importance of such systems gaining wider use. The idea of integrated manufacturing systems, stressed in this part of the conference, laid great emphasis on the organisational changes which will inevitably come about. Technical changes of this kind will no longer involve the replacement of a few obsolete machines with more modern ones, but more frequently the need to modernize the firm completely. It will tend to place a greater premium on knowledge at all levels of the organisation. This will also be accompanied by a transfer of responsibility downwards in the organisation for tasks or decisions which today may be considered the prerogative of management. For example, with the high capital and running costs of such systems an employee must clearly know what to do and be given the responsibility to act quickly and make decisions when a machine breaks down. Overall no doubts remained about the need for planned training to ensure the effectiveness and economies which such integrated systems can bring about. Training was necessary at every level supported by on-going education programmes.

It was suggested that the demands for craftsmen will be fewer but that their work would have to be of the highest quality. The need for technical staff would also grow in most organisations, and this would call for a most careful appraisal and utilization of the available manpower. It is realized in some companies that many existing employees have the qualities and aptitudes for further development if they are given suitable educational programmes to help in up-dating their skills and knowledge. This recognition led to the conclusion that it was necessary to have manpower policies which would positively aid upward mobility. It was quite clear that modern aids to learning must be utilized to the full to enable individuals to reach their potential. This latter point becomes increasingly important when we consider the position of the older worker and the possibility of designing jobs especially for them.

It was on this point that worries were expressed by Mr. Javaux and Mr. Mage. Whilst many younger men had the opportunity to learn, the situation of men over 40 years of age needed special consideration. It was not clear, for example, how one could deal with those employees lacking the intellectual ability to learn. In spite of the goodwill of some employers, they doubted also whether craftsmen wanted to carry out the sort of menial, repetitive and uninteresting work which became increasingly available in some companies, even when the pay was the same as for their previous more interesting jobs.

Professor Koenigsberger stressed the need to seek to develop and upgrade everyone, and suggested that shortage of manpower was the greater risk in industry in general. It was necessary to start planning now so that the new skills needed in future within the labour force could be developed.

A practical difficulty evidenced in the United States was the unwillingness of some managements to divulge their plans because of its possible effects on their competitive position. M. Casserini pointed out that this could only be dealt with satisfactorily by the Unions themselves having positive policies towards these problems.

The discussion on M. Astrom's paper centred round the important question whether society necessarily wanted the sort of technical change which was taking place, and what role the Trade Union movement might best play in forming the society of 1980. This was an important question which we should keep under review.

It was at this point that the question of job satisfaction occupied a great deal of discussion. Dr. Corlett stated that we did not know enough about the factors related to such satisfaction. Consequently we were in a difficulty in setting up industrial organisations to deal with technological innovation.

Bo Jonsson put a different viewpoint by suggesting that Trade Unions should help to shape the direction of change and that the key to the subject lay in using the latent talents of people much more effectively. Trade Unions should seek to break the present monopoly of education and offer greater educational opportunity to everyone.

Whilst these views were generally endorsed, the method of bringing about such policy changes was queried. The inclusion of education and training opportunities alongside wage bargaining was rarely considered. Few Trade Unions appeared to have adequate policies on this point.

Changing Work Duties and Job Profiles

Trends can be seen in a number of countries affected by the impact of new technology, which indicate, quite clearly, that many of the present skills are inadequate for future needs. Trades and jobs currently found in the metal working industry will disappear, due to a variety of factors. Amongst these there will be changes in the raw materials and in the methods by which they are shaped, formed and used. There will be changes in organisation arising, not only from managerial innovation, but also from the social demands of employees. Peter Vos emphasized that "even if we can identify with any accuracy, job profiles for the future arising from technical demand, it might not meet the aspirations of the population. A possible solution might be to adapt job structures to the availalbe labour force".

One speaker told of how his union, in negotiation with management, had indicated that certain jobs would no longer be performed by their members or any employees. This was because the jobs had been so subdivided and deskilled that the resulting work gave little satisfaction to the employee. This point was brought home by a film taken in the factory of a leading car manufacturer. This showed on the one hand highly mechanized production in which the "semi-skilled" worker was a link in the chain of a continuous production process. Everyone watching the film felt uneasy that such work was necessary, involving, as it did, a minimum of knowledge and the use of the worker largely for his muscle power and little else. The work also appeared to be carried out in very noisy conditions in which any form of social contact with other employees was extremely difficult. On the other hand one could not fail to be impressed by the general ingenuity of the manufacturing arrangements, which were clearly dependent on a large number of technicians and more ancillary staff concerned with design, maintenance and control functions. Whilst it was suggested that some "semi-skilled" people would not object to this type of continuous machine minding activity, the general view was that insufficient thought had been given to the problem of how to get rid of such jobs. It was not enough merely to respond to technological change by creating such jobs - Trade Union leaders ought to try to influence trends and to anticipate such developments. Whilst profitability might be the final criteria, safety and human aspects of work were areas where Trade Unions needed to be much more interested and to plan ahead. It was equally clear that those trained for such limited single jobs might be unable to cope with subsequent change.

Social scientists are beginning to be concerned with the idea of "task alienation" involving the alienation from the activity itself, as well as the lack of opportunity for some employees to have a chance of determining the factors in the job in which they are employed. Individuals do not necessarily accept that jobs should be, or need to be designed in the way in which they are currently structured. It was pointed out, however, that jobs are defined primarily as a result of technological change. One possible method of dealing with this is by the idea of the broadening of jobs as a deliberate policy - i.e. job enrichment. Evidence is becoming increasingly available that if a job is made more meaningful and interesting employees will respond by doing better and more efficient work. The question of how to make jobs more meaningful and how to structure organisation to achieve this becomes important. It is doubtful whether we have enough knowledge of social organisation at work to be able to do this in any very ordered way at present. Some attempts have been made to design equipment having regard to the available labour force and its potential for training. It seems likely that the nearer we get to integrated manufacturing systems the greater will be the responsibility for decision-making made upon employees in the organisation. It is, therefore, important that their jobs are structured in such a way to ensure that the responsibilities given to them are within their capacities.

Various other approaches were also considered. It would appear that individuals with a wider range of skills and knowledge at their command can adapt to changing requirements more readily. One way of achieving this is by manpower policies encouraging upward mobility. Vernon Jirikowic suggested that "this was necessary in its own right, because of the need for increasing knowledge in the context of most jobs in industry in the future". He also suggested that it might be necessary "to create opportunities to learn by collective efforts". Whilst Trade Unions have in the main probably concentrated their bargaining power by seeking general improvements in pay and conditions of work, they have possibly undervalued the changes which they could bring about by placing greater emphasis on continued education and training into adult life. The idea of negotiating conditions for vocational training and education is one which is worthy of much deeper investigation. If, for example, it were a requirement that employees should be allowed to proceed in education as far as their abilities allowed them, there is little doubt that the pressure generated for higher technical studies would result in new and improved entry arrangements to further study in higher technical institutions and universities. Fritz Hauser placed importance on providing a broader vocational training as a base from which to develop skills later on. It did not seem to matter whether parts of the basic training were immediately utilized at the individual's workplace. The basic training was much more concerned with ideas of how items are made, how work is organised, about safety factors and attitudes to the manufacturing procedures. M. Casserini reminded those present that the position of women in employment should also be remembered by Trade Unions. Whilst seeking improvements for men we needed to be clear whether we also wanted equality of opportunity for women in both education and training.

Mr. Cowan also emphasized the need to design jobs instead of letting production requirements dictate them. He emphasized that technical and social systems are governed by different rules but are nevertheless dependent on one another. Unfortunately many production engineers in industry seem pre-occupied with the technical problem and fail to understand the possibility of optimising both the social and technical requirement.

He suggested that the possibility of setting objectives for workers might offer another approach to the problem of employee satisfaction. Such techniques are now reasonably well known at the management level, but represent a fairly novel approach for other roles in organisations. Objectives for workers could possibly involve agreements on standards some of which could be expressed numerically and others which could be expressed qualitatively. Although there appear to be administrative difficulties in applying such procedures at shop floor level, early experimental work is encouraging. Development of this idea of setting and agreeing objectives for employees seems important and worth detailed investigation. On the whole, organisations which have developed the concept of management by objectives and corporate planning have tended to be successful. If it is possible to transfer and adapt this concept elsewhere in the organisation, it may represent one of the most significant techniques to be developed in employment. Strong doubts were expressed about the methods and administrative arrangements which would need to be set up for such an idea to be brought into use.

Whilst it is very doubtful whether one can predict job profiles, it is necessary to have manpower policies which deal with change. In view of the changes which seem likely to take place in the next decade, Trade Unions might play a more active part in ensuring that policies are developed concerning manpower budgeting, job design and the provision of additional skills and knowledge for employees. Mr. Leiss objected that too many of present Trade Union policies were related to repairing defects in the industrial set up, instead of being planned with long term aims in mind involving technical, organisational and social change.

The unifying thread of the conference centred around general educational needs for the future. Many differing views were expressed about the organisation and methods employed by educational institutions. Inevitably, philosophical views about education were put forward by some speakers. In spite of the different standpoints from which the subject was viewed, ranging from the strictly utilitarian to the idealistic, it seemed totally agreed that narrow specialisation in education was unacceptable, even for labour market survival. Whilst a narrow education and training might fit someone for their first job, it was clear that it could not sustain them for future needs. One must try to anticipate the sort of society in which people might live and work in the future and it was evident that this would be different from today. Therefore to educate and train merely for today's needs would be to opt out of our responsibilities. It was clear that the demands of the working environment on employers would be greater in the future and would call for greater knowledge, recognition and judgement.

Quite apart from the working environment, the general social environment in which people would live and of which they needed to have knowledge, would be much more diverse than today. This was largely due to improved methods of communication and travel, which not only generated but also emphasized the need to understand different cultures, social organisation, political systems and values. Developments in international trade and economies, in political groupings of countries all had increasing impact on the society in which we live and of which we needed much more understanding. It would lead to greater demands in the arts of communication and of general improvement in literacy and a better understanding of concepts and measurements which can best be expressed numerically.

Whilst this analysis of the situation seems to be accepted and has been recognized by others in the past, one of the major problems is the need for action and changes in policy and procedures to deal with the situation. The first such change must be the recognition of the need for an enlarged base of education at the secondary level which reflects the need for "environmental education" - that is one which takes account of needs of present and future environments. These environments are not primarily concerned with the machine tool or automobile industries but are certainly concerned with a technologically based society.

The biggest changes in policy are probably related to methods of learning as opposed to those of teaching. They emphasize the need for education to be pupil-centred not school or subject-centred. It may indicate a need for more involvement of parents in the educative process. There is certainly a need for further professional training of teachers to enable them to understand the new environments which are evolving and enable them to help in the development of their students.

It is clear that substantial changes in the pattern of industrial training are also taking place in Western Europe. These are much more radical than just a general tidying up of the apprenticeship system. The idea of a broader base to education is complemented by similar trends in industrial training. The conference considered the changes taking place by the introduction of the module system of the Engineering Industry Training Board of Great Britain and by the German Three Steps System described by I.G. Metall. Both systems involve a breakaway from the traditional concept of apprenticeship. They are similar in that both provide a broadly based training in engineering practices. The German system then adds a super structure based on a performance grading of trainees. Georg Benz emphasized that in spite of the changes proposed by the Step System he saw it only as a partial reform. Changes were needed jointly in both secondary education and industrial training. Whilst their plan still needed approval, he foresaw that it could be adapted and enlarged for the training of technicians and, perhaps later, for adult training. He saw also, that it could have a counterpart in training for commercial work.

The British system is more radical than the German, involving supplements of skill, education and training after basic training(so called modules). These enable adaptation to technical change and help new manpower needs to be met. The module system allows for different learning rates for individuals rather than imposing arbitrary time scales for achievement of standards. It also provides a structure bridging all job boundaries by enabling the training of multi-skilled craftsmen. Such craftsmen are enabled by this system to add to their skill and knowledge as the need arises in adult life. Interest was shown in these new developments. However, particular doubts were raised about the way in which existing trade structures would be altered and whether performance standards were best dealt with centrally. It was recognized that these developments in Germany and Great Britain should be closely watched by other countries as they represented a marked break from traditional approaches to craft training.

One objection to the British system (and possibly to the German) is that some part of the basic training which is concerned with the transition from school to work might, with advantage, be better rooted in general education and developed within educational institutions catering specially for post school needs. Such an arrangement, with suitable adaptation, could enable the year before immediate employment to be much more meaningful. Its aims need not necessarily be craft centred but could be cultural and social as well as economic.

Nevertheless, the concept of the module system certainly meets the central objection to the idea of retraining put forward by Seymour that:

> "The most important step to achieve by 1980 in the retraining of industrial workers is the abolition of the idea of retraining all together. We should have become so accustomed to training in industry that we do not think in terms of training and retraining but training and more training".

Seymour suggested that the emphasis in future work will be laid on recognizing essential cues in the work situation. How one knows when and what to do will become more difficult. What one has to do, will tend to become easier. Control skills, fault diagnosis and skills of communication are likely to be increasingly necessary at work. These emphasize that training needs to be system-based and to use the increasing repertoire of educational and training technology. The idea of "system" in this context means that there should be initially an adequate description of what the individual will be required to do in the job. From this, the training syllabus can be derived. Only when this stage is reached can the optimum duration of training be defined, taking into account varying learning rates. A variety of training methods can then be used. Finally the training should be tested to judge its effectiveness and to modify and update it. The system recognizes that all of the activities are inter-related and that change in any one part of the system produces change in the other parts. If we designed training systems in this way we should get nearer to the situation of taking pleasure in learning.

The underlying conviction produced at this conference is that there is a need to concentrate thinking on principles first and methods second. On this basis the seminar seemed generally agreed that:

1. Vocational training in future should only start after a period of broader general secondary education.
2. Post "school" industrial training should be broadly based and accompanied by a continuation of general education.
3. Employees should be provided with opportunities for continued training and education throughout their working life.
4. Organisations should be structured so as to offer opportunities for job satisfaction and for upward mobility of employees.
5. There is a need for much more joint involvement and responsibility by educationists, trade unionists and employers in the planning and development of industrial training and education.
6. Trade Unions and other similar organisations have a responsibility to play their part in bringing about the sort of primary and secondary education more fitted to the individual's need in modern society.

To bring these principles into action we may need to develop new techniques and even new institutions. Many possibilities exist to bring this about within the armoury of manpower policies. In particular it seems that special emphasis should be given to the following:

1. The need for manpower policies and budgeting at plant level. These should be co-ordinated with other policies such as capital investment so that the education and training needs of the labour force can be identified.
2. Manpower policies at plant and national levels should be designed to bring about upward mobility of employees. Further education and training will be a necessary complement to this and will help to prevent the further widening of the educational and training gap between generations.

At the same time research is needed in the social sciences as well as in the physical sciences to discover ways of improving policies and methods, so that they are kept under constant review. "Good judgement requires more than correct opinions; on these topics it also requires that these shall be opinions on the right subjects".

It may well prove necessary for trade unions in particular to review their tactics and strategy so that they may influence the development of policies and plans for education and training at national and plant levels. It seems that their objectives have been geared too closely to traditional collective bargaining demands. They have given insufficient priority to the role of education and training not recognizing that it may well have a greater effect on the improvement of living standards than wage bargaining. Technological gaps referred to in some O.E.C.D. papers are as much to do with education and training as they are with purely economic considerations.

1980 is not far away. One needs to be reminded that many children now at school will be working in industry in twelve years time. Integrated manufacturing systems affecting adult employees will also then be much more commonplace than today. Plans and decisions about education and training policies need therefore to be developed now, ahead of the time of actual implementation. A "laissez-faire" attitude or maintenance of "status quo" on the part of any group in the community may well result in employees getting the sort of education and work they neither deserve nor need. Time and resources need to be devoted to planning for change. An active manpower policy should help to provide the framework for this, but we need action now because the problem is urgent!

TECHNICAL AND MANAGERIAL INNOVATIONS
PRESENT AND PROSPECTIVE
THE MACHINE-TOOL INDUSTRY IN EUROPE

by Dr. Ing. W. SIMON,
Technical University of Berlin
Federal Republic of Germany

Introduction

To obtain as accurate an insight as possible into the situation of West European industry and, more particularly, of the machine-tool industry as a key industry round about the year 1980, it seems advisable to study the trends of development as affected by two spheres of influence:

(a) structural development as the result of recognizable technical innovations;

(b) possible structural alterations connected with market changes between 1968 and 1980.

In order to explore the manifold interactions within the brief limits of this report, and to provide several bases for discussion, it will be well to divide the whole into four sections:

Chapter 1: International characteristics of the world machine tool industries as at 1966-67.

Chapter 2: The most important new technological and production processes - review of the development trends in metal working from 1950 to 1968.

Chapter 3: Possible developments in the machine tool industries of European O.E.C.D. Member countries between 1968 and 1980 under the influence of previously determined components.

Chapter 4: Summary and forecast of the future demands which will be made upon those concerned.

CHAPTER 1: International characteristics of the world machine tool industries as at 1966-67

For our purposes attention should be drawn to the following important figures in Table 1:

TABLE 1

The World Machine Tool Industries in 1966

1	2	3	3a	4	5
Producers in Country-groups	Share (value) in World Production in %	Production (absolute) in 10^6\$	Percentage of Metal-forming	Number Employed	Production/ manpower in \$/manpower
Western Europe	35.3	2,056	28.7%	261,000	7,800
EEC	22.4	1,304	30.4%	158,000	8,300
EFTA	12.7	682	25.0%	95,000	7,200
North America (United States + Canada)	30.2	1,755	28.1%	108,000	16,200
Japan	4.7	272	22.0%	(80,000)	(3,400)
Comecon	25.8	1,500	20.5%	?	?
Others	4.0	230	12.5%	?	?
Total World	100%	5,813			
Exports within the above mentioned groups		1,640 = 28.3% of 5,813			
Shares of world exports %					
Western Europe		59.3			
EEC		41.3			
EFTA		17.0			
North America		14.5			
Japan		3.3			
Comecon		21.7			
Others		1.2			
		100%			

(a) The share of the West European industrialised countries in world output of machine tools in 1966 was 35.3 per cent of a total production value of United States $2,056 millions on which 261,000 persons were employed.

(b) The corresponding share of North America was 30.2 per cent of a total production value of United States $1,755 millions employing only 108,000 persons.

(c) At first sight it appears that the output per employee is roughly twice as great in North America as in Western Europe. This startling relationship of 2 : 1 is however misleading, because when calculating unit dollar prices the official exchange rates between European currencies and United States dollars are taken, and these are not always realistic. In actual fact the relationship is perhaps something like 1.4 to 1 or 1.5 to 1. It is an expression of the technological gap so frequently mentioned today and one may discuss whether the degree of productivity in the United States is already so much higher than in Western Europe and whether it will be significantly altered in the next few years.

(d) One proportion which is certainly not constant is the share of the Comecon countries in the world market, which in 1966 amounted to about 26 per cent. On the basis of all the published plans of the Comecon countries, it seems distinctly doubtful whether this figure will still be so low in 1980. Under the influence of the prevailing rates of growth, the world share of the West European machine tool industries may change considerably. In this connection it may be pointed out that in Eastern Germany and Czechoslovakia today roughly as many persons (about 115,000) are employed in the machine tool industries as in Western Germany (about 112,000). Their output is mainly taken up by the Soviet Union and changes in the market situation there necessarily affect the West European industries.

(e) One interesting characteristic of the world machine tool industry is its marked international nature; the various manufacturing countries export to each other an average of 28 per cent of their output. This may be due to two causes:

(i) The specialisation of individual countries in particular types of machinery and industrial requirements (e.g. Switzerland - watch and clock industry; Sweden - ball-bearing industry).

(ii) The remarkable multiplicity of the demands from all branches of the metal working industry in respect of their most important means of production, i.e. machine tools, cannot in practice be satisfied with the output of a single country.

We may assume that this international character of the market will remain unchanged over the next twelve years even if the distribution of export quotas alters as between individual countries. It is however to be noted that in the highly developed industrial countries of the world the number of those employed in the machine tool industries will never depend solely upon the national demand, but will be strongly influenced by the world market situation. In other words:

> "The national machine tool industry which is backed by the best inventions and the most flexible production techniques, while ensuring high quality and industrial safety, is the most likely to survive and to avoid a decline in employment."

The following figures and table should confirm the foregoing remarks and give a clearer insight into the outlook for the future.

Figure 1

DEVELOPMENT OF PRODUCTION AND EMPLOYMENT
IN THE EUROPEAN AND NORTH AMERICAN MACHINE-TOOL INDUSTRIES

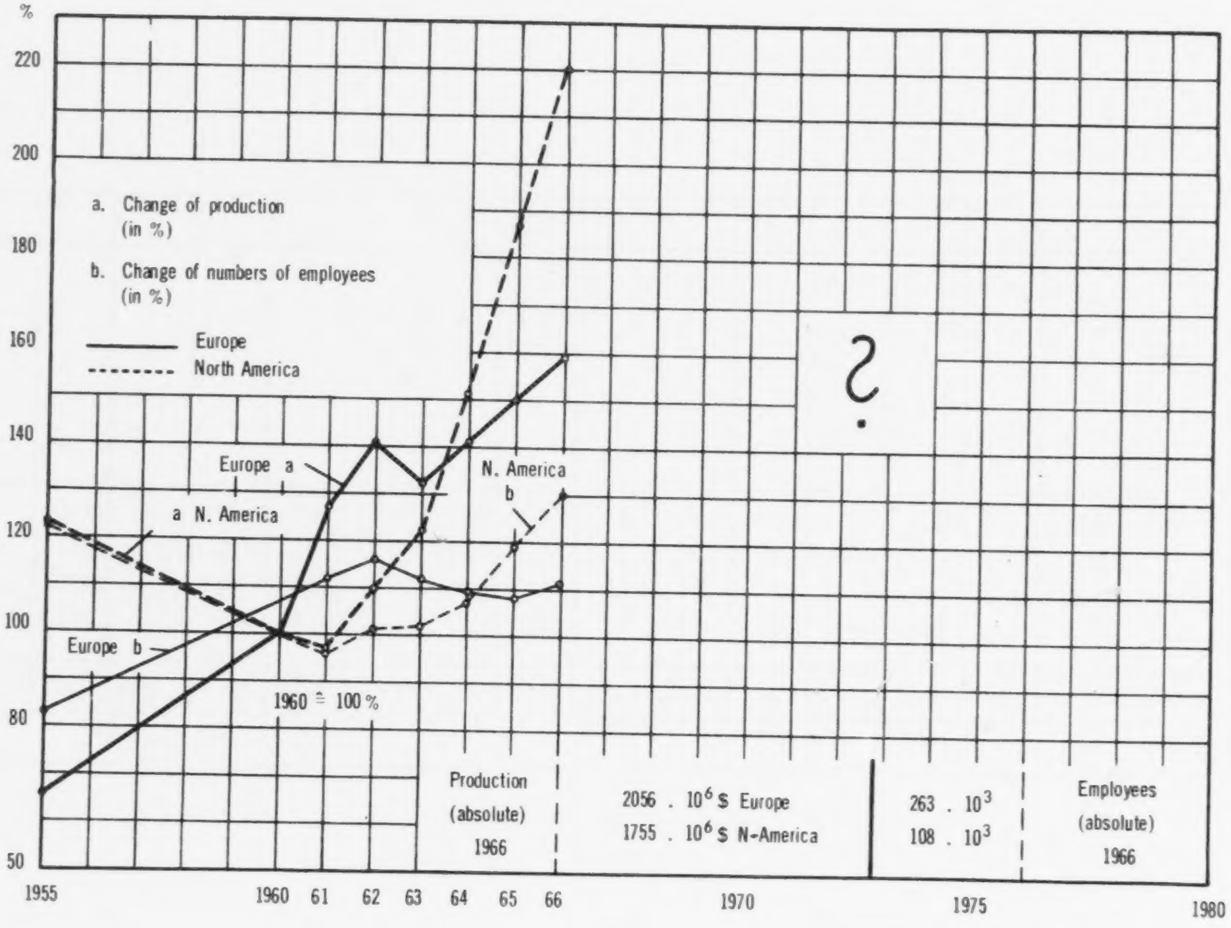


TABLE 2

Development of International Trade in Machine Tools

Country	Exports(in %)								Imports(in %)							
1960 = 100%	1955	1960	1961	1962	1963	1964	1965	1966	1955	1960	1961	1962	1963	1964	1965	1966
Western Europe	?	100	125	142	150	148	157	188	?	100	165	199	190	188	186	197
North-America	?	100	166	160	110	151	136	134	?	100	86	138	146	190	260	344
Japan	?	100	211	149	240	321	425	703	?	100	193	193	100	97	81	41
O.E.C.D.	?	100	139	149	143	153	158	181	?	100	163	192	171	175	176	192
absolute amounts in $10^6$$ for 1966																
Western Europe								978								580
North-America								236								211
Japan								53								34
O.E.C.D.								1267								825

Figure 2

INCREASE OF EXPORTS OF MACHINE TOOLS
1960 = 100 %

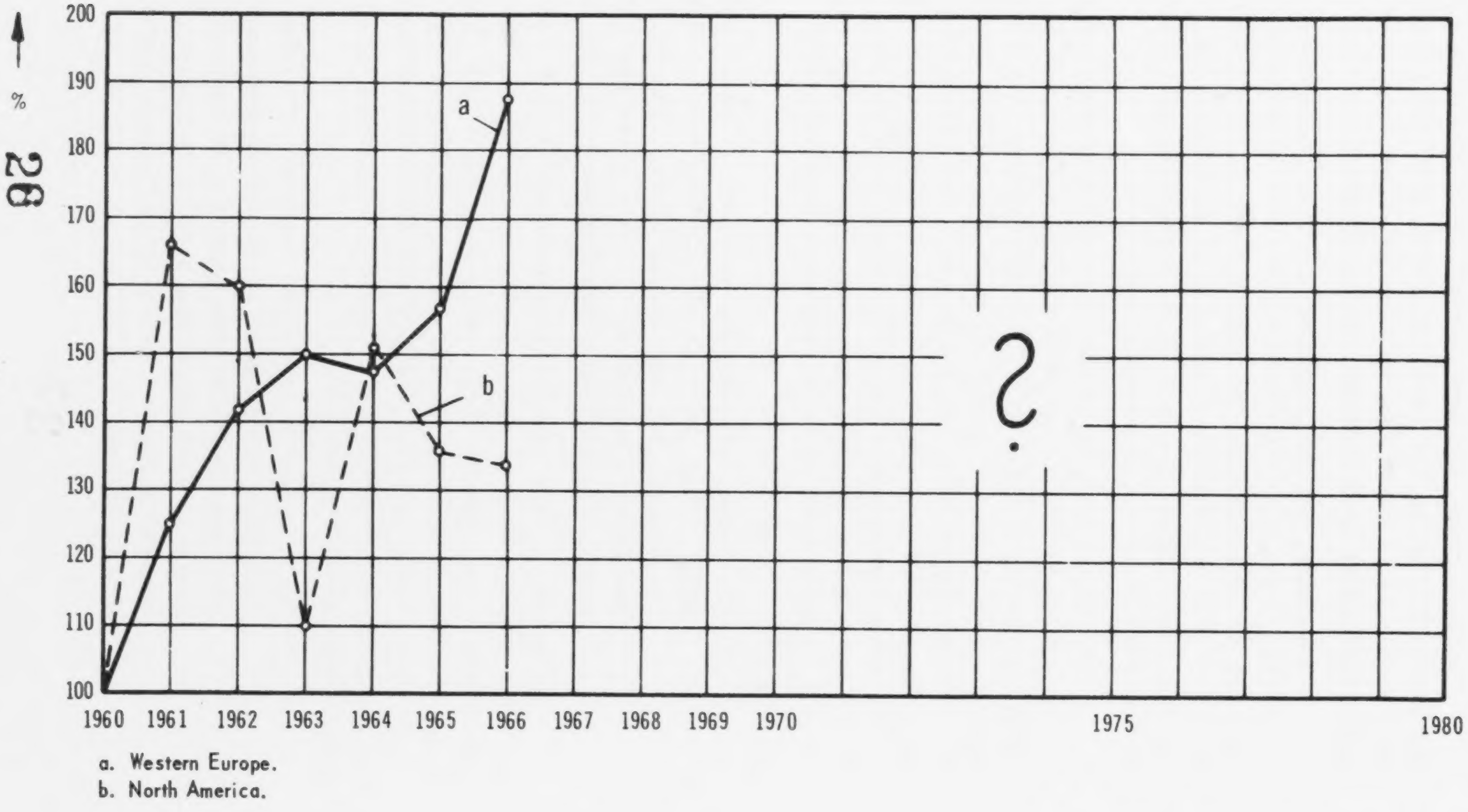


Table 2 shows the development of international trade in machine tools during the same ten years and Figure 2 brings out the remarkable fluctuations in exports of machine tools and their dependence upon external "disturbances".

One thing, however, emerges clearly from these three figures and table, namely, the impossibility of obtaining any reliable forecast for the next ten to twelve years by the simple extrapolation of previous trends. This recognition is important for the composition of a reliable forecast of machine tool production such as we have undertaken.

Before we pass on to the next section, some mention must be made of the characteristic structure and size of firms in the world machine tool industries. Table 3 shows the statistical distribution of employees per firm in the machine tool industries of various countries. For purposes of simplification four categories of firms have been chosen. A slight imperfection is that the figures were drawn up in different years in different O.E.C.D. Member countries, but the dates are given in each case so that certain inferences may be drawn. The most notable results are two:

(1) The relatively large proportion of small and very small firms, both in the United States and in Europe. The figures for the United States show no less than 566 firms with 1-9 employees: these small firms are mostly specialised subcontractors for the large firms.

Thanks to this specialisation in particular components or sub-assemblies for a fixed circle of customers, numerous small firms can justify their existence, while the large firms are relieved of certain special production lines. The statistics do not make it clear whether the same pattern is widespread in Europe; and it would be desirable to analyse the European industries in this sense.

(2) The average in the upper category of firms - 1,350 employees per firm in Europe and 1,700 employees per firm in the United States - is relatively small compared with other branches of industry; there is however a trend towards rather larger firms in the United States.

Other conclusions might be drawn from the above statistics, but they would lead too far at this point and can, if required, be drawn into discussions about optimum size and the kinds of co-operation of smaller firms. However, Table 4 reproduces the statistical data of Table 3 as regards the comparison between Europe and the United States in graphic form.

Summarizing the elements of the firt Section, we have the following approximate picture:

1. Today (1966-67) Western Europe still leads the world production of machine tools with a labour force of 261,000. Whether this position can be maintained until 1980 seems to depend chiefly upon three factors:

    (a) Increasing production capacity in the United States.

    (b) The growing pressure of deliveries from East European countries, and

    (c) The practical use made of West European inventiveness and technical skill in new forms of organisation embodying all new technological possibilities.

2. It is not possible to obtain a reliable picture of 1980 by extrapolation from the market records and statistics for recent years; fresh bases for forecasting must be sought.

3. The subjects of optimum firm size and the organisation of the division of work between large and small firms merit serious discussion.

TABLE 3

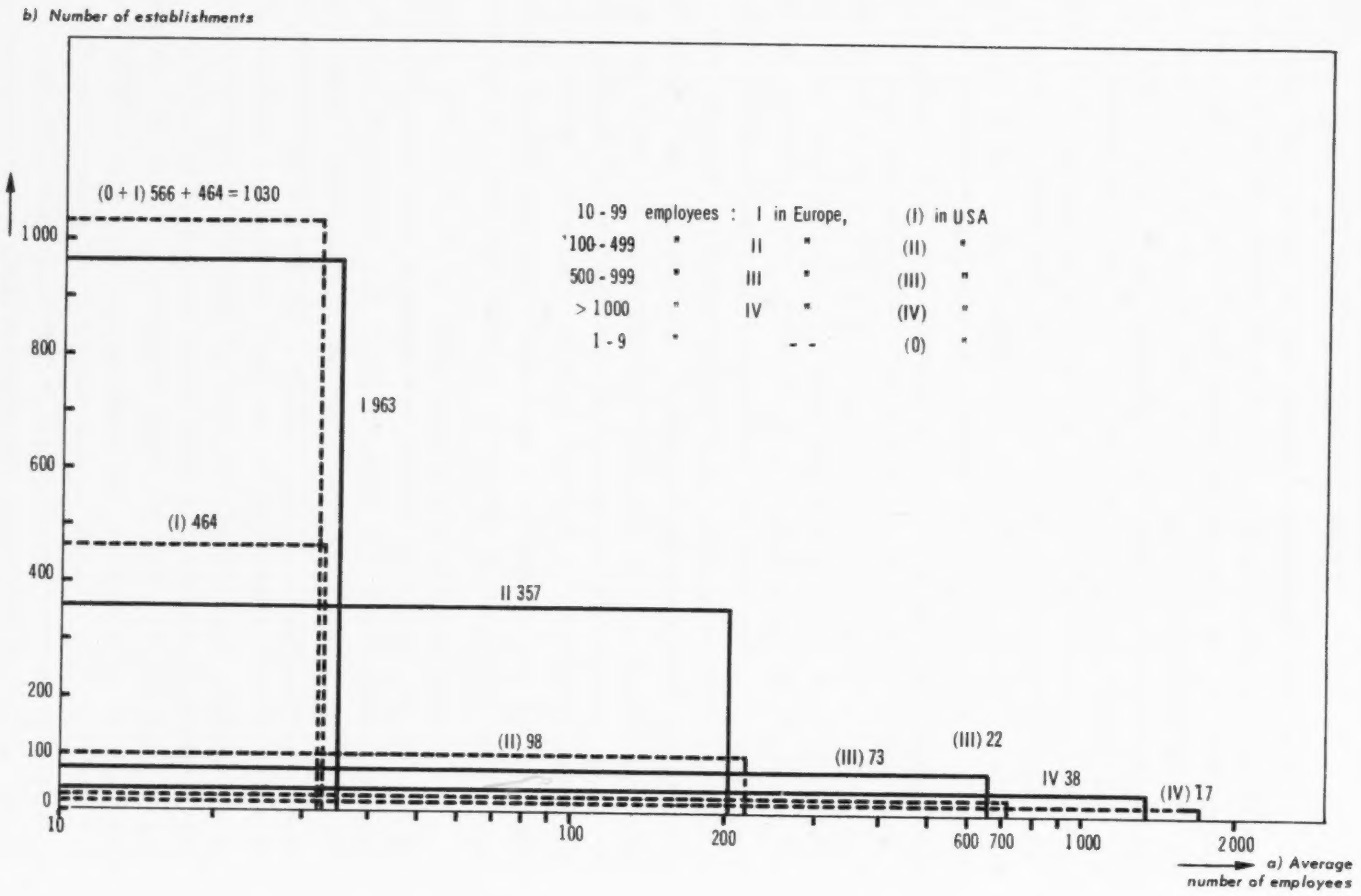
Sizes of establishments and numbers employed in the European and American machine tool industries

	4 Categories of establishments									
	I (10-99)		II (100-499)		III (500-999)		IV >1000		Total	
	N	E	N	E	N	E	N	E	N	E
Germany (1966)	261	9.076	145	34.256	35	26.162	15	22.274	456	91.768
E/N		35		236		748		1.490		200
France (1967)	173	5.300	36	7.400	7	4.400	4	6.400	220	23.500
E/N		31		206		630		1.600		107
Italy (1966)	287	8.730	33	6.270	-	-	-	-	320	15.000
E/N		30		190						47
Belgium (?)	16	662	9	1.940	2	1.013	-	-	27	3.615
E/N		42		216		506				134
Netherlands (1967)	17	1.780	3	750	-	-	-	-	20	2.530
E/N		104		250						127
United Kingdom (1966)	63	2.488	102	16.632	20	9.974	15	17.684	200	46.788
E/N		40		163		500		1.180		234
Sweden (1966)	26	1.000	9	1.600	2	1.400	-	-	37	4.000
E/N		39		138		700				108
Switzerland (1966)	120	4.700	20	4.800	7	5.200	4	5.300	151	20.000
E/N		39		240		745		1.320		133
Europe	963	33.746	357	73.648	73	48.149	38	51.658	1.451	207.201
E/N		35		206		660		1.350		143
United States (1963)	464 (+566)*	14.710	98	21.469	22	15.583	17	28.965	601	81.127
E/N		32		220		706		1.700		135
Europe + United States	---	48.456	455	95.517	95	63.732	55	80.623	2.032	288.328
E/N		33		210		670		1.470		142

N - number of establishments.
E - number employed.
* - Firms with less than 10 employees.

Table 4

NUMBER OF ESTABLISHMENTS AND AVERAGE NUMBER OF EMPLOYEES IN EUROPE AND USA



CHAPTER 2: The most important new technological and production processes - review of development trends in metal working from 1950 to 1968

The most important innovation, which has influenced procedures in all branches of metal working industries since about 1950 is the concept of numerical control. Interest today is still concentrated on N/C machine tools, although N/C testing machines, wiring machines and drawing tables are already on the market. N/C machine tools may be described as "machines that understand measurements", by way of expressing the fact that the movements of the slide which determine the shape of the workpiece are already dictated by the measurements of the workpiece design. For a long time Western Europe unfortunately failed to appreciate the fundamental significance of this concept and considered the process as a special technique for special machines. It is only in the last five years that Europeans have realized that, given the ease with which numerical programmes can be changed in connection with suitable machines, they have a prime means of improving the flexibility of their machining processes with fewer rejects and of introducing automation into even short runs. The machine tool industries must take their place not only as makers of N/C machines but also as users, since the conditions of manufacture of machine tools are "made to measure" for N/C machines, namely: mostly short runs, rapid adjustment to a customer's special requirements, high precision, frequent shortage of experienced machine-operators etc.

At approximately the same time electronic data processing found its way from the realms of commerce into metal working plants. And now first came to light the fundamental significance of coupling related machines through a programme formulated in terms of numbers. It is, perhaps, the most significant characteristic of the situation in Europe that only in 1967-68 did an understanding dawn of what a radical change this development would bring about in the next twelve years in the metal working industry and especially the machine tool industry. It is no longer a question of replacing a few obsolete machines with more modern ones, but in many cases of the need to reorganise the firm completely so as to permit the integrated data processing of management, construction, job preparation, production and sales.

Experience shows that this conversion process may take five to ten years:

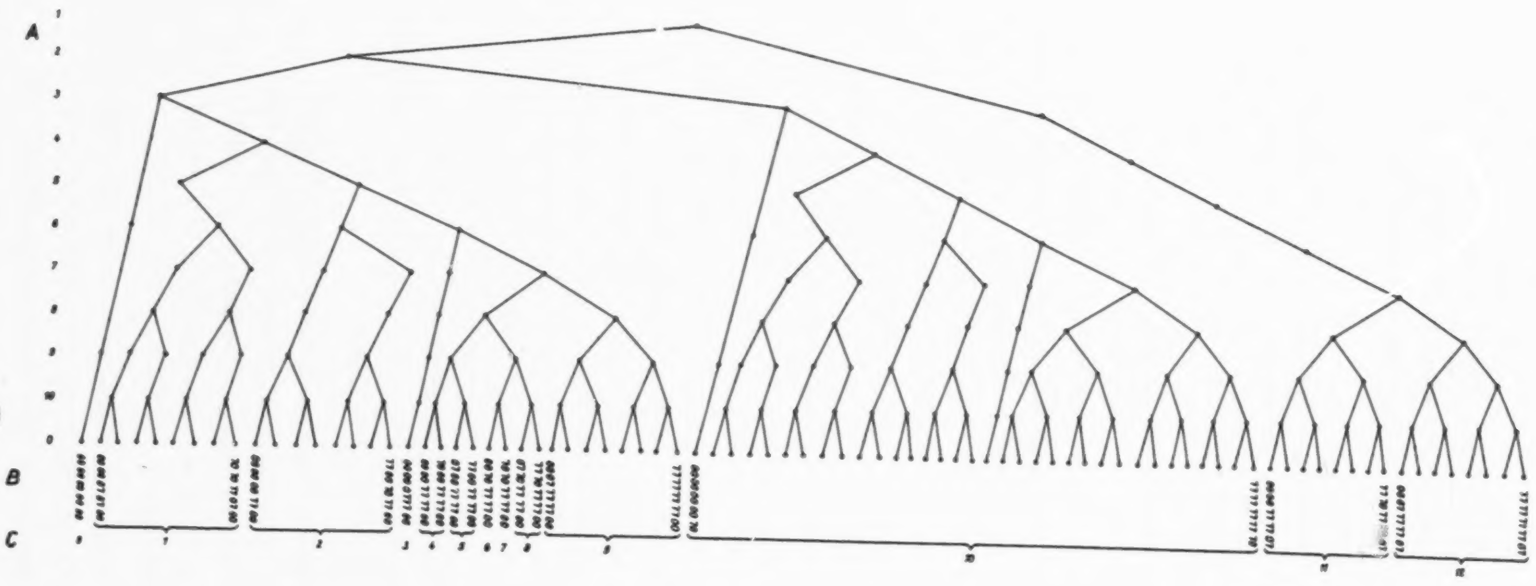
At this point we will refer only briefly to the close connection between this technical development and training problems. This will be dealt with at greater length in Chapter 4.

It seems, however, advisable to formulate more precisely the possible technical developments which may be discerned as the pace-setters for change in the industrial world. For this it is unfortunately necessary to refer to some theoretical work. Figure 3 shows a possible development diagram for automatic machine tools presented in logical order so that it can be understood both by men and by computers. Without going into details here, we may simply say that it shows a very large number of possible combinations of data processing equipment and more or less automatic machine tools of all kinds. In order to express the data of Figure 3 in generally comprehensible form, the theoretically possible combinations according to Figure 3 are reduced to 13 specifications in List 1. The result is a mathematically accurate scale of automated machine tools from 0 to 12, in which Stage 0 represents the old mechanization of hand-operated machines and Stage 12 a conceivable form of complete manufacturing control through a central process computer, which is still a remote contingency and could probably only be used in special cases. Between the two stages we have the present multiplicity of equipment. Under Section 3 some practical analyses will be elucidated by this method. It seems that this diagram may serve not only to bring some order into the confusing variety of forms, but may also make it possible to compile mathematically clear statistics of means of production, to obtain reliable forecasts of development possibilities and thus approach the goal of forecasting 10 to 20 years ahead.

The trend described above, which affects the future development of single, short and medium production runs, is accompanied by some special technological innovations which in individual cases certainly offer the possibility of better materials processing than previous methods.

Table 5 attempts to compare these processes and their present applications. Quite apart from the fact that all processes call for special machines and equipment, which may

TOPOLOGICAL TREE FOR THE DEFINITION OF A SCALE FOR AUTOMATIC CUTTING MACHINE TOOLS



A. SET OF DEFINED BINARY ATTRIBUTES

INDEX NUMBER	ATTRIBUTE	RANGE OF VALUES O	RANGE OF VALUES L
1	On-line computer control	no	yes
2	Off-line computer control	no	yes
3	Path information storage	no	yes
4	Type of path information storage	inflexible	flexible
5	Loading of information store	inside	outside
6	Auxiliary information storage	no	yes
7	Adaptive control	no	yes
8	Kind of control	point-to-point	contouring
9	Automatic tool change	no	yes
10	Number of controlled axes	$\leq 2\frac{1}{2}$	≥ 3

B. BY MEANS OF THE RANGE OF VALUES AND THE INDEX NUMBER OF THE ABOVE ATTRIBUTES DUALLY CODED SCALE AND

C. ITS COMPOSITION INTO 13 STEPS (DATA REDUCTION FOR VERBAL DESCRIPTION)

NODES : Possibility of choice, where the actual value of the attribute concerned is assigned to the corresponding index number.

Let a missing node be equivalent to the value "O" at the index number concerned.

BRANCHES : Bent to the left correspond to the value "O";

Bent to the right correspond to the value "L" of the range of values.

Thus, in the whole, $2^{10} = 1024$ different machines can be differentiated; but this tree shows only 84 types of machines, which can be thought of at the time.

TABLE 5

Comparative Performance of various new methods of machining

	Type of process	Max. metal removing (I) cm^3/min	Max. penetration rate (II) mm/min	Accuracy (III) 10^{-3}mm	Max. Surface finish (IV) 10^{-3}mm	Applications 1968
(A)	Ultrasonic and abrasives	0.02 - 1.2	2.5 - 5.0	5 - 25	0.25 - 0.75	Machining of hard and brittle materials; semi-conductors techniques
(B)	Spark erosion	0.001 - 7.0	10 - 15	5 - 100	0.25 - 5.0	Machining of moulds for plastics, glass etc.
(C)	Electron beam	0.003 - 0.02	60 - 200	2 - 25	---	)Micro machining;)cutting of hard)materials with)high melting)points (e.g. drilling of watch)jewels)
(D)	Laser beam	ca. 0.008	1000 Cutting speed in cutting tin of 25 mm thick	5 - 120	---	
(E)	Plasma	ca. 80	250	1500	500	High speed flame cutting; rough turning of difficult materials
(F)	Chemical milling	---	25 . 10^{-3}	25 - 250	0.75 - 2.5	Etching processes of all kinds (e.g. for printed circuits)
(G)	Electro-chemical profiling	10 - 16	12.5	5 - 125	0.15 - 0.75	Electrolytical turning, milling, trepanning, honing and polishing of metals
(H)	Electrolytic grinding	0.3 - 0.8	2.5	12.5	0.2 - 0.75	Combination of grinding and electro-chemical machining, esp. for tungsten tools

certainly be described as "new types of machine tools", thus swelling the already large number of combinations, special attention should be drawn here to processes B, G and H. These are already widely used today as "reduction processes" and have a future in the machine tool industry itself. We must however point out that electro-erosion and electro-chemical machining call for profile tools that act as information stores and can be rationally produced if necessary on numerically controlled milling machines, since such tools are needed only in very small quantities. The same holds for all profile tools for forming metals and plastics (dies, pressure and die-casting moulds, cutting tools, etc.), so that we may sum up as follows:

> By the use of profiling N/C machines, tool production is in certain conditions substantially cheaper and metal and plastics working and the use of reduction processes are simplified.

In this connection it may be noted that the production and use of plastics increases by 20 per cent each year all over the world.

Another possible way of making machine tool production more flexible, in order to meet various customer requirements at minimum cost, consists in the skilled use of unit components. If we succeed in making progress towards the national or international standardisation of engineering sectors, the prospects of unit components will be substantially improved. There is absolutely no doubt that, as regards central development and national standardisation possibilities, the totalitarian economies of Eastern Europe have certain advantages; whether and to what extent these are rationally used is in the long run dependent on international market conditions. Here we may refer back to Chapter I.

The following five points may be taken as a basis for discussion on Chapter II:

1. Figure 3 presents a "topological tree", permitting a broad view of the scope of technical development over the next 10 to 20 years.
2. Data reduction to 13 development stages easy to describe verbally provides a generally intelligible guide to the use of the method.

3. The most important factors influencing technical development in the next few years derive from the rapid expansion of N/C machines and the rational use of data processing equipment in the production sector.
4. The increased use of unit components and the standardisation of engineering sectors are also of economic importance.
5. Previous technological innovations have undoubtedly considerable significance in individual branches of the metal working industry; but in the machine tool sector they seem to have less influence than the factors referred to in 3 above.

CHAPTER 3: Possible developments in the machine tool industries of European O.E.C.D. Member countries between 1968 and 1980 under the influence of previously determined components.

Discussions on Chapter 2 should have made it clear that the development of the European machine tool industries in the next twelve years will very probably be concerned with practical analyses of the problems of numerical control and integrated data processing and the consequent increases in flexibility and output. Compared with these important tasks, the details of technological development set out in Table 5 seem less significant, except perhaps the increasing use of plastics. Accordingly we cannot go far wrong if we confine outselves to begin with to the two most important problems of innovation.

In List 1 thirteen groups of machine tools were listed in terms of ever more complete degrees of control through the flow of information from other sections of the works. In practice, however, we shall never have to deal with a unified outfit of machines belonging to one group but always with mixed groups.

The general task for management is therefore to pursue a long-term policy of innovation within the limits of what is possible from the point of view of finance, manpower and organisation, and destined to produce a rational mixture of machine tools.

And here it should be noted that automatic machine tools in the higher range (see List 1) have a higher utility quotient, owing to the reduction in idle and make-ready times and the possibility of setting one man to control several machines and a run-on over several shifts, and thus a higher production potential than machines in the lower range. On the other hand, the latter are mostly cheaper and better adapted economically to long runs than the N/C machines. A firm's innovation policy can therefore easily be detected in the changes in composition of the various groups over several years. Figure 4 shows how such a change may appear.

Here are set out the combined machine fleets of four progressive German firms in the metal working industry with some 1,200 machine tools (= 100 per cent) and about 2,500 employees, and the trend in the distribution over the last ten years is also shown. It is striking to note the very high proportion of the machine group 0 (though it is relatively declining) and the hesitant purchase of N/C machines from 1961-62 onwards.

Figure 5 shows the percentage group distribution at the end of 1967 for these four firms. By referring to the diagram in Figure 3 each firm is now able to adjudge its status quo and to make its own auto-critique.

By and large, there are probably three factors delaying the rapid progress of innovation:

1. The relatively high investment costs as we move up the scale, although this argument, all too readily used, does not always represent the true reason.
2. Somewhere about Stage 4, the compulsion is increasingly felt to change factory organisation in the production cycle in line with the greater inter-machine flow of data. If it is intended to convert the whole works to automatic integrated data processing, including computer-aided design, automatic programming and flow of materials (production control) experience shows that eight to ten years will be needed. Naturally enough the tendency is to proceed step by step and in many instances to content oneself for several years with a partial solution.
3. Changes in organisation are bound up with personnel training, which begins with the management and ends with the machine-operator. It is precisely this essential but long-drawn out period of training right up to the top management which probably forms the most valid excuse for procrastinating with such far-reaching innovations.

Figure 4

TIME DEPENDENCE OF FREQUENCY DISTRIBUTION
OF THE STAGES OF AUTOMATION
(ACCORDING TO LIST I)
IN FOUR GERMAN FACTORIES

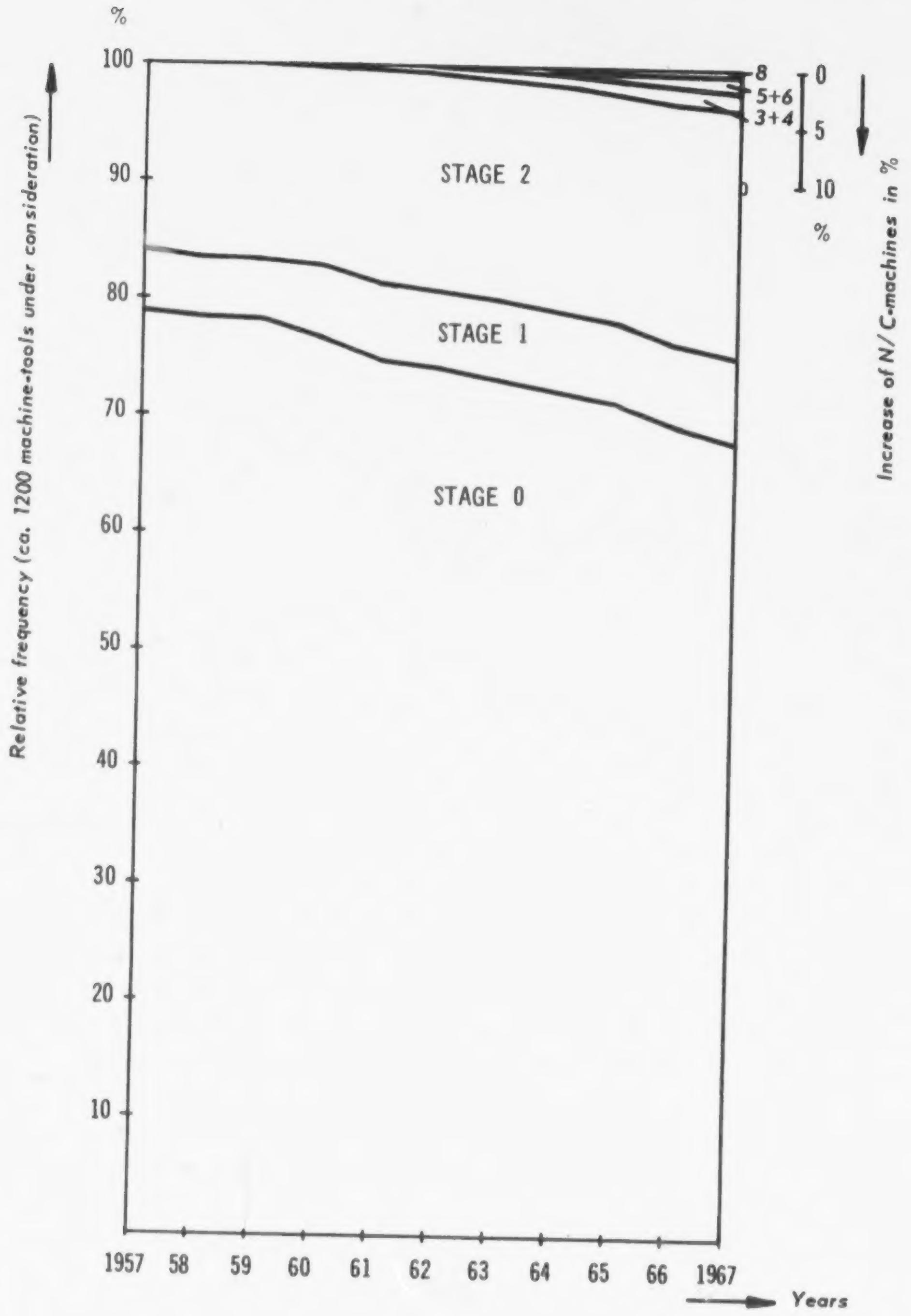
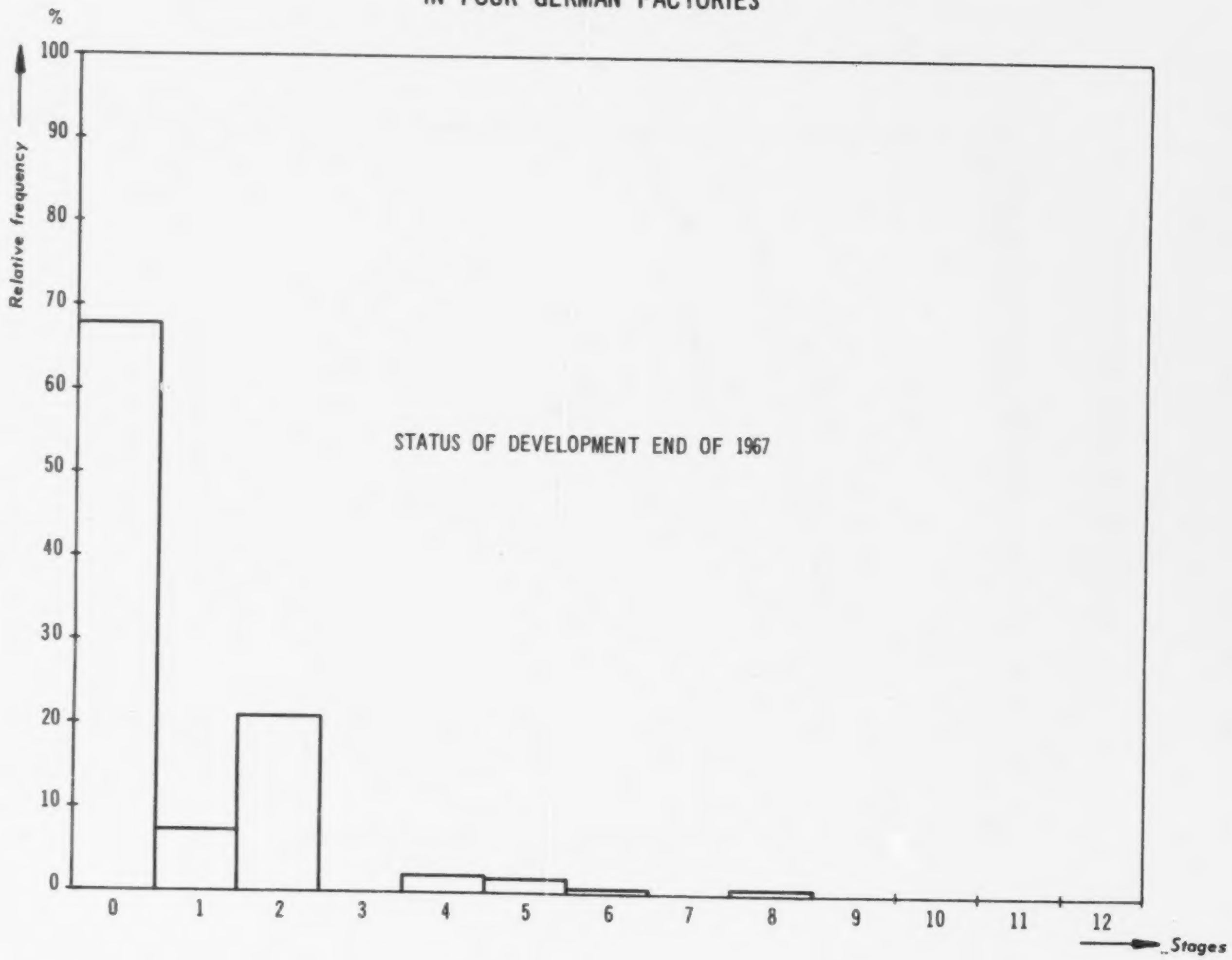


Figure 5

FREQUENCY DISTRIBUTION OF THE STAGES OF AUTOMATION
IN FOUR GERMAN FACTORIES



In this context it may be mentioned that we have just begun a study about the relation between N/C - machines of different stages (see Figure 3) and plant organisation. As a first result an adaptation-curve of plants to N/C - problems is given in Figure 6. Proceeding from the first 10 stages the scale "a" shows the influence of N/C machines on plant organisation in per cent; in the case of 100 per cent influence it is supposed that a N/C - system of stage 9 will entail a total change of plants, including buildings, production controls by computers and a wide range of training methods. It has already been mentioned that experience has shown that a total change of organisation will take from 5 to 10 years. In the scale "b" a medium duration of 7.5 years is supposed for a change of 100 per cent. Thus it seems possible to have a first look at the adaptation-times influenced by innovations with the aid of N/C - machines and computers under economic conditions. A detailed publication on this matter entitled "Investitionsentscheidungen im Rahmen der Beschaffung neuzeitlicher Fertigungsmittel" (Investment decisions for the procurement of modern production equipment, Hanser Verlag, Munich) is now available.

So far we have spoken only of the factors which hold back the further development of production techniques and the conversion of undertakings. However, in the course of Chapter 1 we have already referred to the impulses given by events on the international market which stir up a perhaps latent readiness for innovation. There are three principal considerations which may encourage management to accelerate measures of modernization which are overdue:

1. The lag in productivity behind the United States demonstrated in Table 1.
2. The maintenance of a competitive position in respect of production costs and quality.
3. The maintenance of a competitive position in respect of flexibility, response to customers' special wishes and short delivery times.

This comparison of the factors which delay innovation with those which promote it, which are of an economic or organisational and psychological nature, bring Chapter 3 to a point where it is ready for discussion. Summing up we may say:

1. The modernization of the metal working industries and more particularly the machine tool industries in Europe demands the most effective mixture of means of production.
2. Innovations in the production line must have as a prerequisite changes in the organisation particularly with regard to more rapid flows of information and materials. The organisational changes can be speeded up through the installation of data processing equipment which will shorten reaction times throughout the firm.
3. As a result of movements on the international market it is vitally necessary for the European machine tool industries to come to grips speedily and seriously with the problems set out here if they wish to maintain their position in the world for the next twelve years.

However, despite all these certainly important pronouncements, we are no nearer our objective, which is to work out a suitable basis for forecasting future employment structures. One solution may therefore be suggested in the following Chapter.

CHAPTER 4: Summary and forecast of the future demands which will be made upon those concerned

After giving a usable scale of automatic machine tools in Figure 3, whereby every plant manager can arrange his machines as shown in Figures 4 and 5, we would suggest going a step further in systems engineering and analysing each stage simultaneously from the technical, economic and sociological standpoints, (see the publication mentioned above). Figure 7 shows such a comparison for Stage 5 as an example. The technical diagram U is essentially a combined material and data flow chart in which the full cycle time t_d from the factory order (system entry E) for a workpiece up to the finished and tested piece (system exit A) is resolved into processing times t_1 to t_7 in the individual processing stations; in this connection it is irrelevant that t_1 to t_5 relate to data processing and t_6 and t_7 to material processing and testing. M designates material inputs; M_1 is the raw material, M_2 the tools and M_3 the clamping devices. The shorter the running-through time, the more flexible the system. If the computer C is of such dimensions that computer-aided design can be carried out in the design office G and

Figure 6

ADAPTATION OF PLANTS TO N.C.-PROBLEMS

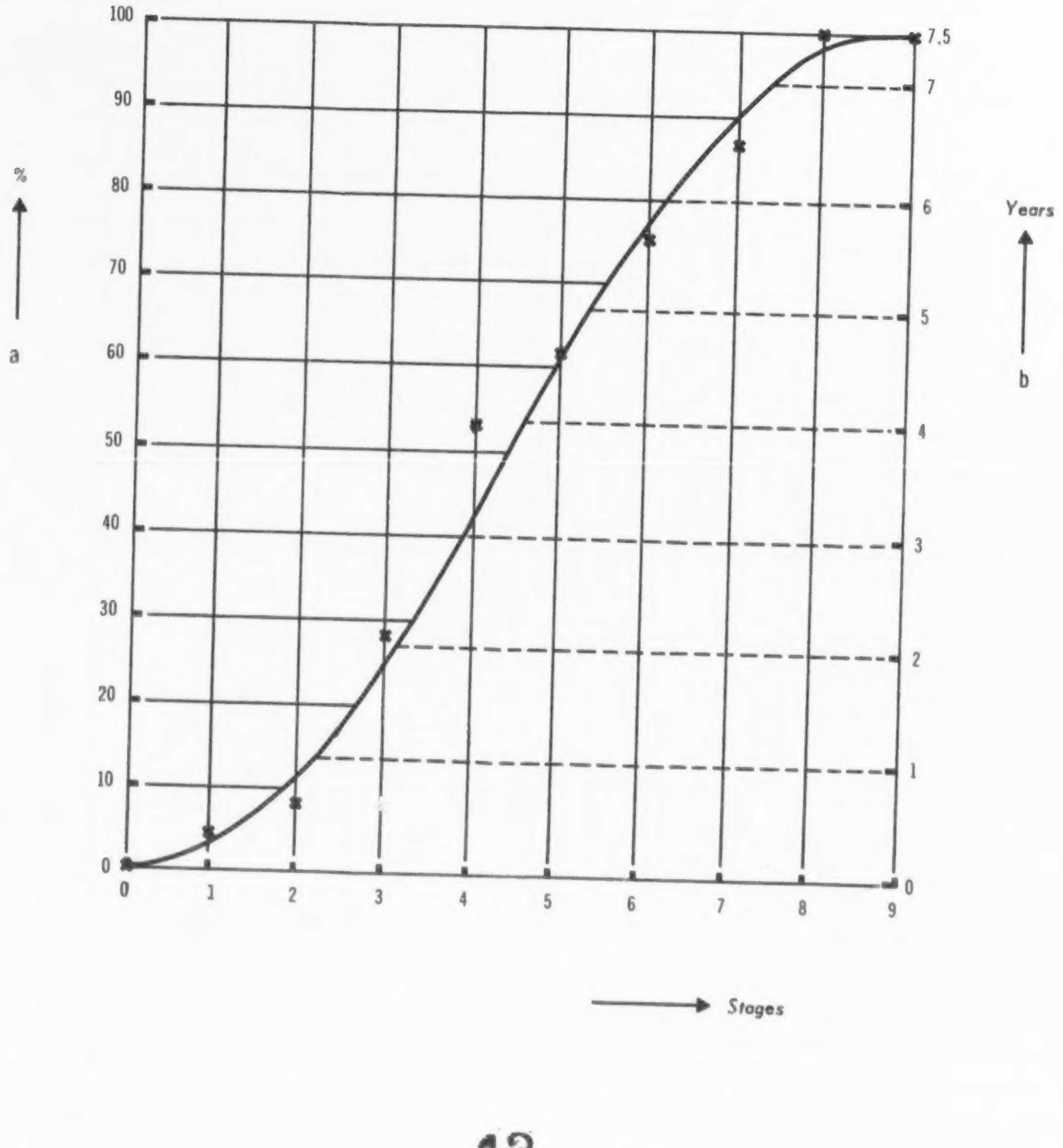
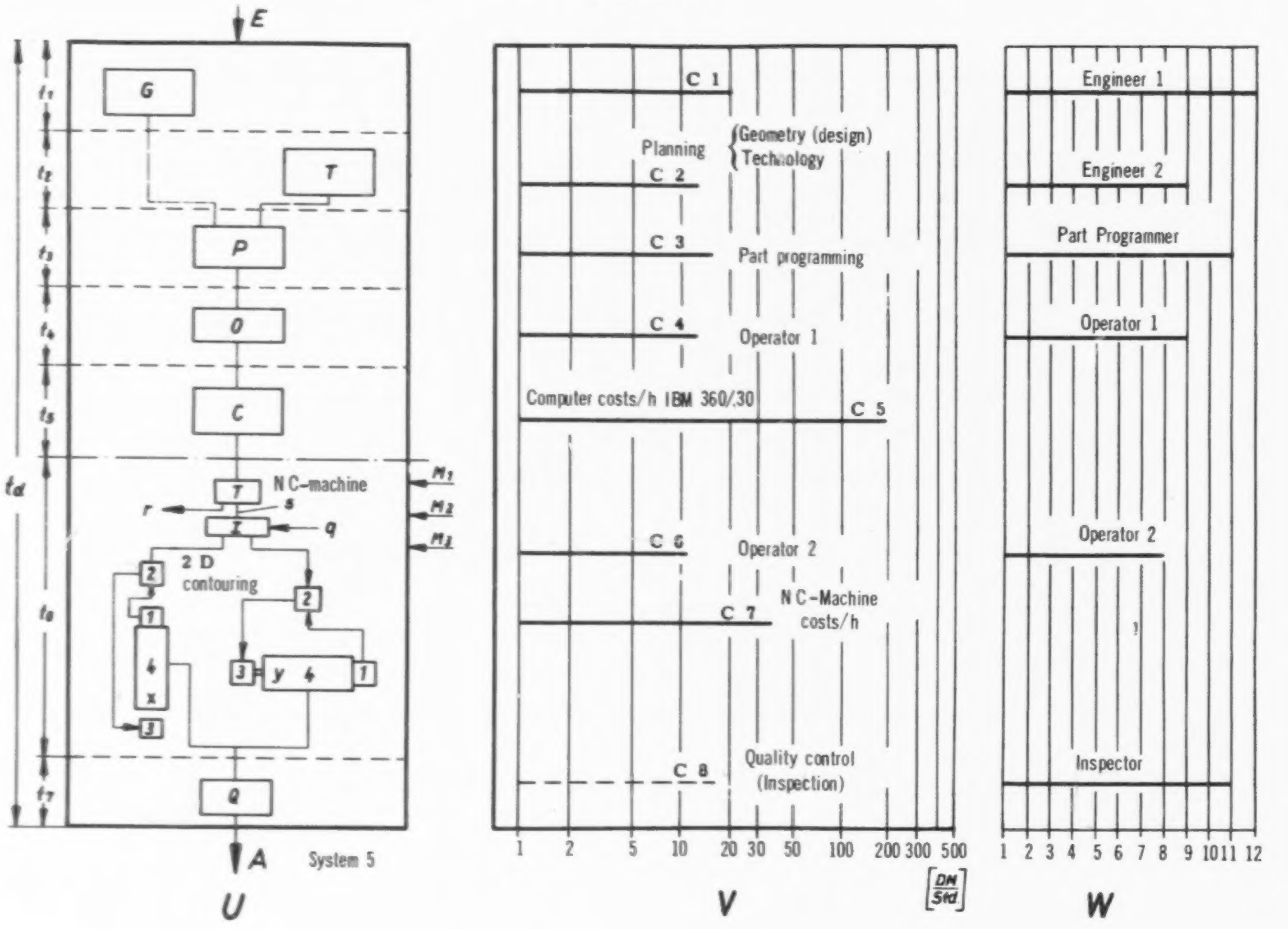


Figure 7


E
G
T
P
O
C
T
N C-machine
r
s
q
2 D
contouring
2
1
4
x
3
2
3
y 4
1
Q
A
System 5
M_1
M_2
M_3
t_1
t_2
t_3
t_4
t_5
t_d
t_6
t_7
U
C 1
Planning
Geometry (design)
Technology
C 2
C 3
Part programming
C 4
Operator 1
Computer costs/h IBM 360/30
C 5
C 6
Operator 2
C 7
N C-Machine
costs/h
C 8
Quality control
(Inspection)
1
2
5
10
20
30
50
100
200
300
500
[DM/Std]
V
Engineer 1
Engineer 2
Part Programmer
Operator 1
Operator 2
Inspector
1
2
3
4
5
6
7
8
9
10
11
12
W

computer-aided programming, e.g. with programming languages like APT, EXAPT, etc. in stations T and P, then times t_1 to t_3 are very short in comparison with conventional methods and the full cycle time t_d is very favourable with an N/C machine.

This does not mean that the costs for this special workpiece would be a minimum in every case. In Column V the costs per hour for every processing station are shown logarithmically:

The exact total costs C_p are sometimes obtained from the sum of the products of time and costs per hour

$$C_p = \sum t_i \cdot c_j = \sum t_i \cdot t_j$$

With this method we have an essentially more accurate cost picture than with the costing diagrams normally used hitherto, so that the planners can make more reliable systems analyses than before when studying the profitability of various stages of automation. This is the main condition for increasing the use of N/C - machines of the upper stages.

In Column W we have tried to evaluate the workplaces belonging to the individual processing stations according for the present to a supposed 12-stage scale. Whether that is correct or legitimate we do not yet know; in any case we can work out a generally valid diagram on this basis, which describes each of the new workplaces with adequate accuracy and makes it possible to grade them.

With a group distribution similar to Figure 5 and the diagram in Figure 7 we should in principle be able to define the new workplaces not only qualitatively but also quantitatively. However, our research has not yet got that far. On the other hand, by working from Stages 0 to 12 we can already recognize quite clearly the trend of changes in workplace structures and can draw conclusions for operator training. Owing to the difficulties outlined in Chapter 3 in particular, it is not yet possible to make a quantitative forecast of requirements of skilled workers; but a whole series of qualitative requirements in connection with vocational training can certainly be discerned. Under the influence of the developments described above, the whole top management will have to be sent back to school.

LIST 1

Outline of a scale of automated cutting machine tools according to information and tool store criteria and computer link-up (verbal description of line C in Figure 3)

Stage:	Characteristics:
0	Machine tools with no notable stores, with no automatic control systems and no internal data processing, but possibly with numerical position indication to facilitate measurements.
1	Machine tools with inflexible slide-path information stores (produced by an external processing, e.g. templates, gauges, patterns, cam-discs etc.) for analogue control systems, but possibly with automatic auxiliary functions through logical link-ups (e.g. push-button controls).
2	Machine tools with flexible, manually adjustable slide-path-information stores in internal data processing (e.g. programme drums, numerical decade switches etc.) for analogue or numerical control systems, possibly with automatic auxiliary functions.
3	Machine tools with flexible slide-path information-stores produced by a simple external data processing (e.g. manually adjusted punched tape) for numerical 2-axis positioning controls, with no automatic auxiliary functions.
4	Machine tools with flexible information stores as output of an external data processing (e.g. punched tape) for all work functions, (co-ordinate data, preparatory and miscellaneous functions) for numerical 2-axis and multi-axis positioning and straight-cut control systems, but without tool-magazine and no tool-changer.
5	Machine tools as in 4, but with tool store (e.g. turret, tool-magazine, etc.) and automatic tool changer.
6	Machine tools with flexible information stores from external data processing (e.g. punched tapes) for all work-functions and for numerical 2- and 2 1/2-axis contouring control, but without tool store and no automatic tool changer.

Stage:	Characteristics: (Cont'd)
7	Machine tools as in 6, but for numerical 3-axis and multi-axis contouring controls, without tool stores.
8	Machine tools as in 6 and 7, but with tool stores and automatic tool changer.
9	Computer centre for off-line operation (punched or magnetic tapes) in connection with machine tools of the stages 1 to 8, as well as computer-aided-design, automatic programming and production control, possibly with use of remote data transmission.
10	Machine tools as in 4 to 9, but with adaptive control.
11	Machine tools of the stages 4 to 9 with link-up a process-computer (real time and on-line operation), without data carriers (e.g. punched or magnetic tapes), automatic workpiece changer, but without adaptive control.
12	Process computer system with machine tools as in 11, but with adaptation control on the individual machine tools, as well as computer-aided design, automatic programming and production control.

PRESENT AND PROSPECTIVE
TECHNICAL AND MANAGERIAL INNOVATIONS
THE AUTOMOBILE INDUSTRY

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Introduction

Students of the history of engineering often find it difficult to distinguish between (a) general technological developments giving rise to novel design ideas, and (b) revolutionary designs creating the need for corresponding technological developments in the fields of raw materials, manufacturing processes, etc.

This paper is to deal mainly with problems concerning the automobile industry, and here again it is difficult to make a clear distinction. As far as the terms of reference for this seminar are concerned, the principal features which distinguish the automobile industry from other engineering industries are due to its producing consumer goods, designed for various but predetermined markets, in large quantities. Although in this respect the automobile industry has been in a special position for many years, it is doubtful whether this will continue, because new processes, procedures and machines for metal forming and metal removing operations are becoming more and more suitable for a wide variety of applications and the boundaries between processes and equipment for very large, large and medium scale production tend to become less clearly definable. Already today technological, economic and human considerations must often be approached from points of view other than those concerning merely batch sizes. Many of the points mentioned in this paper will apply, therefore, as much to a large part of the engineering industry in general as to the automobile industry in particular.

Quite generally it can be stated that the men and women who have to deal with the design and manufacture of various products must possess not only the knowledge and skill of their trade but also the ability to use the correct approach in selecting and employing efficiently the opportunities offered by the latest developments in their fields of activity.

In this connection mention must be made of the developments in the field of engineering materials, developments which affect the work of designers as well as that of production engineers. The former must choose the available materials most appropriate for particular purposes, the latter must determine the most efficient ways of handling and processing them. The scope of this seminar is limited to aspects concerning the metal worker. It excludes, therefore, the considerable developments in the field of polymers which will no doubt play an ever growing part in industrial production. A plastic gear box housing for motor cars has already been successfully produced and used in an experimental vehicle, and many components which today are still manufactured from metal will certainly be made from suitable synthetic materials within the next 20 years.

On the other hand, metallic materials will be required when special properties such as very high resistance, especially creep and/or heat resistance, stiffness, high strength-to-weight or stiffness-to-weight ratios, etc., are needed to obtain satisfactory technical and economic efficiency.

However, materials which thus satisfy the designer's requirements may present problems to the production engineer. High stiffness under working loads may result in correspondingly high forces being required for carrying out forming operations, the light alloys may have to be machined at high cutting speeds if satisfactory surface qualities are to be obtained, and the conventional machining of materials having high shear strength and hardness, may lead to large cutting forces, low permissible cutting speeds and correspondingly low metal removal rates (Figure 1)(1). As this would mean a reduction in production performances, it would counteract the general need for increasing productivity and must be prevented.

The problems must be attacked on the broadest possible front involving the complete manufacturing system (Figure 2)(1). It is, however, not only in research that this attack must be mounted. It is necessary to take into account the full complexity of interrelations between product design, raw materials, as well as installation, application and utilization of suitable plant and equipment (Figure 3). Technological, operational, economic, organisational and human problems must be covered and these will now be discussed in greater detail.

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(1) From M.E. Merchant, The manufacturing-system concept in production engineering research, C.I.R.P. Annals, Volume X, No. 2. (1961-1962).

1. Technological problems

Manufacturing processes

Workpieces of specified shapes and sizes can be produced by:

(a) forming or moulding the raw material;
(b) removing surplus material from a piece whose overall dimensions are larger than the required workpieces;
(c) combining (a) and (b), by first forming roughly shaped pieces and then reducing them to their accurate shapes and sizes by removing the remaining surplus material;
(d) joining pre-produced sub-component parts by welding, brazing, etc.

Forming and Moulding

The cutting out of complicated shapes from solid blocks of raw material by removing large quantities of surplus metal, particularly in the form of chips, during roughing operations, not only represents a waste of material and effort but also creates problems of swarf removal and disposal which may become serious at high metal removal rates. Such use of orthodox chip removing processes may still be practised in cases of one-off orders for prototypes, models, special tools, jigs, fixtures or odd repair jobs(1), but it is more than likely that in the production of general engineering consumer goods, metal forming processes will be employed on an ever increasing scale for creating the basic overall shapes. Only if the forming process cannot produce the required dimensional accuracy or surface finish, the manufacture will have to be completed by some chip removing finishing process.

Moulding and forming processes, such as casting, forging, deep drawing of sheet metal parts, etc., usually require relatively expensive patterns or dies, the cost of which is justified only when it can be distributed over large size batches. Moreover in the orthodox processes, e.g. sand casting or drop forging of billets, considerable skill is needed in preparing the sand moulds or in operating the forging machines. The operations involved are often rather lengthy quite apart from the fact that some require heavy and costly machinery.

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(1) An exception is the "System 24" manufacturing system (see paragraph 2.3.2), which differs greatly, however, from "orthodox" methods both in the design of the machinery employed as well as in the planning, progressing and control of the operations involved.

It is likely, therefore, that other processes, which can be applied with lesser operational skills and which are already available or in the process of being developed, will be employed to a growing extent. The required workpiece shapes may then be produced from powdered or molten metal (e.g. powder metallurgy, investment or die casting), or by plastically deforming solid raw materials (e.g. cold forming or extrusion). High energy-rate forging methods using stored energy (Dynapak) (Figure 4)(1) or internal combustion in cylinder-piston units (Petroforge) may be employed, whilst sheet metal components may be produced by means of 'hydroforming' or high energy-rate methods using explosive charges (Figure 5)(1) or electro-magnetic energy (electro-magnetic forming) (Figure 6)(2). In most of these processes only one die (female) is usually needed for the forming of sheet metal parts, the material being forced into the die when the energy is released. This means that expensive matching of male and female dies is not necessary and that the tooling cost is considerably reduced, thus making the process economical for relatively small batches. The high energy-rate forming processes are particularly useful when applied to those workpiece materials (e.g. nimonics or stainless steels), which are difficult if not impossible to form by means of other processes.

Cutting

The processes employed for finishing components either after preparatory operations or by machining from solid can be divided into those serving for two- and those serving for three-dimensional cutting. The simplest method of cutting out two-dimensional profiles - mostly from plate material - consists in severing the surrounding surplus material from the required profile by a single slot-cutting operation, e.g. by a bandsaw.

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(1) From W. Johnson, High Energy Rate Forming of Metals, The Manchester Association of Engineers, 1962-1963.

(2) From M. E. Merchant, loc.cit.

Higher operational speeds can usually be obtained by means of the oxy-gas and oxy-arc processes but these are suitable only for cutting low carbon steel and are of relatively low accuracy. Stainless steels, light alloys and other so-called "difficult" materials, can be cut by the plasma jet (Figure 7)(1), where energy densities are such as to make high cutting speeds possible (about 4 times those of oxy-acetylene cutting), although the obtainable dimensional accuracy and surface finish are not very good. Even higher energy densities, of the order of over 100,000 kW/cm^2 are obtained with electron beam machining (Figure 8)(1). At such densities the workpiece material is no longer melted but evaporated, and by deflecting the beam electron-magnetically the profile to be cut can be controlled to a high degree of accuracy. This process is particularly suitable for cutting materials of low heat conductivity and high melting point.

The cutting operations mostly applicable to the automobile and allied industries are, however, those which serve for producing three dimensional profiles, whether they are of a simple rotary (male or female) nature, such as cylindrical or tapered shafts or holes, screw threads, etc., or more complex as in the case of crank shafts, connecting rods, bell crank levers, gas turbine blades, etc. In the cutting operations which are employed for this purpose the surplus material is progressively removed in small quantities, usually in the form of chips, and the final workpiece shape depends upon the path which the cutting edge or face of the tool describes relative to the workpiece material. Any wear of the cutting tool affects, therefore, the accuracy of the product, unless special precautions for tool wear compensation are taken.

New developments of the processes employing single or multi-point cutting tools aim at making them applicable to the machining of "difficult" materials, at raising their technical and economic efficiency by increasing rates of metal removal, at reducing tool wear and improving the obtainable workpiece quality (accuracy and surface finish), or at both. In addition, processes have been developed for cutting complex shapes by means of profiled tools which are relatively easily produced, and which are fed into the workpiece material under the control of the machine.

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(1) From H. Opitz, Stand und Bedeutung der Technologie der Fertigungsverfahren, 11th Aachen Machine Tool Colloquium, 1962.

In the development of one single point cutting process, "hot machining", a current passing through the cutting tool and the workpiece heats the shear zone of the workpiece material immediately in front of the cutting edge (Figure 9)(1). This reduces the cutting resistance of just that portion of the workpiece material which is to be cut. As a result "difficult" materials are now machinable with higher rates of metal removal (lower cutting forces), less tool wear (longer tool life) and better surface finish than would otherwise be possible in the machining of less "difficult" materials and with negligible effect on the mechanical properties of the finished workpiece, provided optimum cutting conditions and current settings are maintained (Figure 10).

Although the roughing out of complex shapes from solid materials is generally uneconomical, the waste of material in the form of chips or swarf may sometimes be more than compensated by gains of productivity if roughing and finishing operations can be combined and executed at high speeds. An example is the application of high speed plunge grinding with profiled grinding wheels(2). By increasing the circumferential speed of the grinding wheel from 20 m/sec to up to 90 m/sec - which necessitates of course appropriate grinding wheels, proper safety precautions and suitably designed machine tools - the rate of metal removal during cylindrical plunge grinding can be raised from

$$\frac{10\ \text{mm}^3/\text{mm grinding width}}{\text{sec}} \text{ to } \frac{115\ \text{mm}^3/\text{mm}}{\text{sec}},$$

without detriment to the quality of the ground surfaces. Moreover, with slightly reduced grinding speeds better quality surfaces can be produced than with conventional speeds.

By means of plunge grinding with profiled wheels, relatively complex shapes can be generated without the need for continuous control of the relative positions between cutting edge and workpiece, because the shape and dimensions of the workpiece are determined by the profile of the grinding tool and the control of the infeed movement. The same principle is employed in the electro-mechanical and electro-chemical machining methods which use either abrasive, corrosive or thermal techniques for the production of shapes which cannot be produced by grinding.

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(1) From G. Barrow, Machining of High Strength Materials at Elevated Temperatures using Electric Current Heating, Annals of C.I.R.P., Vol. XIV, 1966.

(2) H. Opitz and K. Gühring, High Speed Grinding, Annals of C.I.R.P., Vol. XIV, 1968.

In the ultrasonic machining process cavities are produced in accordance with the shape of a rapidly oscillating tool, an abrasive being fed into the gap between tool and workpiece (Figure 11)(1). A high degree of accuracy can be achieved (5μ) and the rate of metal removal is the higher the more brittle the workpiece material.

Amongst the electrical machining techniques used for producing relatively large size components from electrically conducting materials, two processes, electro-spark and electro-chemical machining with three-dimensionally profiled tools are perhaps the most important.

In electro-spark machining the spark gap between the suitably shaped tool and the workpiece is kept constant by a servo-control designed to maintain a predetermined breakdown voltage across the gap (Figure 12)(1). Material is removed by melting and evaporation from both the tool and the workpiece, and it is important to ensure that the cutting conditions are so arranged that the "tool wear" (metal removal rate from the tool) is less than the rate of metal removal from the workpiece. The higher the metal removal rate (up to 5,000 mm^3/min) the poorer the surface finish, with sometimes detrimental effects upon tensile fatigue properties, but surface finishes of 0.3μ can be obtained with low metal removal rates. The process is used for the manufacture of moulds and dies from hard steel materials, worn tools being employed for roughing out the cavities, and new tools for finishing them to their required dimensions and surface quality.

Finally, in electro-chemical machining an electric current passes between the workpiece (anode) and a suitably shaped tool (cathode) both being immersed in a continually replenished electrolyte. As a result metal is removed from the anode (the workpiece) and washed away by the electrolyte (Figure 13)(1). High rates of metal removal (up to 15,000 mm^3/min) and good accuracy and surface finish can be obtained and there is no tool wear, if cutting conditions are right. This process will perhaps make the greatest inroad into the domain of today's still conventional machining operations, as it is accurate, requires relatively simple machine motions, and can produce intricate shapes without difficulty (once the tool has been made). It requires, however, correctly designed tools to allow for overcut (see Figure 13) and careful control of the cutting conditions.

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(1) From H. Opitz, loc. cit.

In conclusion, manufacturing processes are now available which can improve production efficiency and deal with the problems created by the newly developed and technologically essential materials. The metal worker of the future will have to be prepared to plan and carry out their application either as a replacement of or in parallel with the more orthodox processes which will themselves have been developed towards greater efficiency. The term metal worker is used here in its widest possible sense, because the pure craftsmanship of the plater, turner, miller or grinding machine operator of today will be less needed and will be superseded by the technological knowledge and judgment which are required for deciding when and how to apply the various processes.

The possibility of combining different processes for similar operations may present a further task to the metal worker of the future, because it will involve a grasp of a much wider field than that concerning a specific type of operation. For example, one can well imagine that a complex three-dimensional profile will be pre-forged or pre-cast, roughed down to approximate dimensions by profile milling and finished to close tolerances and a high quality surface finish by electro-chemical machining. The installation, setting and operation of the machinery in question will require considerable mechanical, metallurgical, chemical and electrical knowledge. During the actual cutting operations the operator will have to observe ammeters, pressure gauges, oscilloscope screens, etc., so that he can adjust or alter settings when the conditions require it, rather than visually watching the interaction between tool and workpiece, e.g. the forming of the chip.

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(1) From A.E. de Barr, Modern Metal Removing Techniques, The Chartered Mechanical Engineer, March 1966.

In other words, the training of the metal worker must also enable him to judge if and when to step in, in case an operation does not proceed according to plan. With the much more costly machinery he needs the ability of correctly choosing and adjusting the machine settings and carries the responsibility for keeping everything in the best possible working condition. This becomes even more important when valuable fully automatic machines are employed.

Computers

Although today too little use is still made of the opportunities provided by the computer, the trend appears to change rapidly and it can be safely assumed that in 1980 computers will be widely used for a large variety of applications. Apart from the operational control of automatic machine tools, which will be discussed later, the computer will be employed

(a) for aiding the design and planning engineer;
(b) for classifying detail parts, sub-assemblies and complete units;
(c) for implementing group technology methods in the production process.

Design and Planning(1)

"The existence of an environment conducive to the effective utilization of the personnel employed in a design department is as essential as in any other place of work ... the material factors involved include the provision of up-to-date draughting equipment, adequate clerical services and efficient data retrieval systems. Amongst the latter should be included a full cross-referenced catalogue library, a coded file of existing detail drawings and a schedule of computer programmes(2)".

The computer will certainly be widely used for carrying out the calculations for a variety of design problems, thus not only reducing the time previously required but also making problems accessible to calculation, which previously could be tackled only by lengthy trial and error methods. Programmes have been developed, by means of which not only strength and stiffness calculations are carried out in order to determine the required cross sections of component parts subjected to specified loading conditions, but also scale drawings of these cross sections are produced. It is, however, important to remember that design calculations cover only a small part of the designer's work. After the calculations and the overall design of layouts of a product have been completed, the preparation of detail production drawings, a time consuming operation in the drawing office, is of vital importance to the success of a new design.

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(1) Computer-aided Design, NEL Report No. 242, Ministry of Technology, London, August 1966.

(2) From Organisation of the Design Function, Machine Tool E.D.C., National Economic Development Office, London, December 1966.

The use of the American "Sketchpad" is but one example of the available facilities. This system provides the designer with a means of sketching parts free-hand on the screen of a cathode ray tube, the computer preparing an exact drawing which can be rotated, scaled or moved about, stored and later recalled or completely erased.

Before detail drawings are sent into today's orthodox machine shop their production must be planned and the drawing together with the machining specification handed to the machine operator. The operator interprets the requirements specified on the drawing and the planning card and converts them into machine and tool settings. With the aid of the computer a schedule of the required machine settings can be prepared almost straight from the design calculations and layouts so that delays are reduced and possibilities of error practically eliminated.

Classification

The importance of variety reduction as an aid to improving the economics of production has long been recognized. From the application of the principles involved, e.g. when Henry Ford offered "any colour as long as it was black", to the introduction of wide ranges of industrial, national and international standards for elements, components and units which could be applied to a variety of products, designers and production engineers have endeavoured to reduce the times and efforts needed for special set-up requirements of machine tools and equipment and to increase the quantities of products which could be manufactured in batches, preferably in specially laid out workshops. Standardisation enables the designer to concentrate all his energy on the solution of new design problems, without having to waste time and effort on those problems for which solutions are known or which can be more efficiently dealt with by specialists.

Whilst national and international standards cover a large number of general purpose units and components, there are still many parts which must satisfy special requirements but which have at the same time a considerable amount of common features. If such parts are coded according to their detailed features they can be classified and grouped according to their technological requirements in such a manner as to obtain benefits which are similar to those found with more general standardisation. This "Group Technology" method involves therefore the grouping of manufactured components according to those features which affect their design and manufacture, rather than their functional characteristics. It may lead to considerable economies in design and production, because it results in variety reduction, particularly if "families" of parts can be produced on specially selected machines or groups of machines. These families can be based on similarity in shapes of the component parts, which would then be produced by common or almost common manufacturing operations. Part families may also be formed of components apparently dissimilar in shape but related by one or several common features which require similar manufacturing operations. This leads to the possibility of producing relatively large quantities of workpieces made up from a number of smaller batches of different components and this in turn reduces the amount of "work in progress" on specific parts with resulting lower storage costs etc. Figure 14(1) shows such a group of components which can be produced on a special surfacing and boring turret lathe without chuck or tool change. The cutting tools required for these operations and set up in the turret are shown in Figure 15(1). If the drawings of all components which have to be produced are coded according to their shapes, their detail features can be easily grouped and standardised. It is also possible to keep on record not only the performance data needed by the designer but also the corresponding planning and costing data, thus greatly facilitating the work of the planning engineer.

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(1) Dean, Smith & Grace, Keighley.

If all these data are stored on punched cards, the work of designing and planning can be carried out by the computer, which in fact may directly prepare a control tape for the machining of a component that consists of a number of "standardised" and recorded form elements.

In conclusion, the computer will not cancel the need for competent designers and planners, but it will no doubt reduce the required number of those who today carry out only routine work, once the principles have been established. Such work can be left to the machine which draws on its stored information as originally prepared for general use by high class designers and planners, and applies and combines the different items to suit the specific requirements.

Accuracy of Manufacture

Doubts are often expressed about the value and usefulness of high accuracy requirements. Accuracy for its own sake is, of course, to be avoided, but if accuracy can result in increased economy of production, it is fully justified. Manufacturing accuracies specified in present-day acceptance tests for so-called commercial application of machine tools are of the order of I.S.O. qualities IT 5-7, and are easily achieved in normal production. They make possible the production of workpieces in such a manner that about 80 per cent satisfy the conditions of interchangeability. For non-selective interchangeability machining, accuracies to higher I.S.O. qualities are necessary. If the saving in assembly cost is then greater than the increase in machining cost, high accuracy is not only economically justified but essential (Figure 16).

It can be achieved by making full use of the facilities which are now available for guiding, driving and measuring the movements of machine tool parts. The order of magnitude of accuracies obtained by the introduction of optical and electronic measurement and control devices is such that it would often be uneconomical to reduce proportionately the corresponding manufacturing limits of the machine tool. It is, however, possible - by means of additional controls - to improve the accuracy to which the machine tool can produce its workpieces, without increasing the accuracy with which the machine itself has been manufactured. For example, with electronically controlled machines, it is possible to measure continuously the transverse deviations of carriage, table and slide movements from their required rectilinear path, to transmit the results of these measurements to the control devices, and to correct the control signals in accordance with computer calculations which ensure that the resulting relative positions between the tool cutting edge and the workpiece material are satisfactory.

Whilst, however, such alignment error compensation is generally possible only on a machine tool on which the movements of the various carriages and tables are electronically controlled, inaccuracies of hydrostatic slideways can be corrected directly by correspondingly varying the oil film thickness so that the resulting movements of the carriage follow a straight path of high accuracy. For this purpose the range of oil-film thickness variations must be greater than is practicable in usual hydrostatic bearings. A bearing pad has, therefore, been developed which can operate with relatively thick oil films without a loss of stiffness(1). The variation of the oil film thickness is controlled by means of valves which are operated by photocells as soon as a deviation of the movement from a reference light beam or laser beam disturbs the equilibrium of the control circuit (Figure 17)(2). Such a system has the following advantages:

1. The working accuracy and sensitivity are independent of absolute measurements as the valves cease to operate as soon as the deviation from the light beam becomes zero.
2. Apart from the control valves there are no moving parts and therefore no wear problems.
3. Investment and maintenance costs are relatively low.
4. Machine tools designed to work with such devices can be produced in accordance with today's commercial tolerances. If they are called upon to carry out work of higher accuracy the electronic control equipment can be purchased separately and applied to the machine if and when required.

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(1) G.S.K. Wong, Interface Restrictor Hydrostatic Bearing, Proc. Int. Mach. Tool Design and Research Conference, Manchester 1965.

(2) From G.S.K. Wong and F. Koenigsberger, Automatic Correction of Alignment Errors in Machine Tools, Int. J. Mach. Tool Des. Res., Vol. 6, 1967.

It may be mentioned that such a system has been tested in the laboratory and errors of up to 0.15 mm (error rate about 7.5μ per second) have been corrected to an accuracy of 8μ. The industrial development of these ideas is still in its infancy but many production engineers will have to change their opinion if they consider that a workpiece must always be less accurate than the machine tool on which it has been produced!

2. Operational and Economic Problems

It has been frequently stated that the possible increase in the available manpower is not likely to match the needed and planned increase in production capacity. This means that productivity per man must be much higher in 1980 than it is in 1968. If our standards of living are to be raised, high productivity must be combined with economic efficiency, i.e. the optimum utilization of manpower must be achieved at lowest possible investment and running costs for the workshop equipment employed.

Automation

Technological developments of processes, tools and procedures have led to the possibility of longer tool lives, increased cutting speeds and higher rates of metal removal; however, with manually operated machines the effective operational speeds, which determine floor-to-floor times are determined by the manpower available for operating a given number of machines and by the limitations of the human operator's mental and physical capabilities. The operator's task has been eased by the provision of electrical and mechanical devices which operate the machine movements, allow more leisurely pre-selection of machine settings during preceding operations - i.e. without loss of production time - and control operational sequences by means of trip dogs and cams. Although such mechanization results in an increase in productivity and reduction of machining costs, it still requires the individual attention of skilled machine setters. The application of fully automatic controls using programmed inputs which may have been recorded on punched cards or tapes, on magnetic tapes, plug boards or in any other manner, will result in the reduction of the mental and physical strain for the operator, in operational speeds being much higher than those one human brain and two hands per machine are capable of and in a reliability and consistency of performance unaffected by human fatigue or error. This does not only apply to forming and cutting operations but also to assembly. The cost of manual assembly depends upon the quality of component manufacture (see Figure 16). In the case of automatic assembly, non-selective interchangeability is not only economically advantageous but also functionally essential!

In the "automatic" factory the manpower required for handling the plant and equipment is not only concerned with running the machines but also with preparing them for action and keeping them in a state of high performance efficiency. In other words, the "skilled craftsmen" must be backed by programmers and maintenance engineers. These men require a much more thoroughly universal training than the operators who are trained for working full time on one machine; they will have to deal with a very wide range of techniques, plant and equipment, but their actual number per machine will be less, thus resulting in higher output per man. This can be further improved if the programming operation is also "automated", e.g. by a computer producing the final tape from the design information (see pp. 51 and 52).

Technical Efficiency

The application of automation can be fully effective only if the information input covers all eventualities with which the equipment has to deal. Different from manual operation, nothing can be left to the intelligence of the "controller". Every step must be clearly planned and incorporated in the programme, so that every deviation can be corrected as required. This is perhaps a blessing in disguise, as it prohibits haphazard planning, which may not be detected if an intelligent man, operating an orthodox machine, has to make his own decisions when definite instructions are lacking. Such a practice may make it possible to get on with the job, but it leads to slackness, and possibly increased cost due to inefficient execution of the work in hand. The automatic operation with feedback control also ensures that the settings of speeds, feeds, the positioning of carriages, etc., as well as the execution of the work are in accordance with the programme which may either have been prepared specifically by the programmer or satisfied by a proved standard procedure which has previously been sub-programmed, stored and fed into the control programme by manual or automatic means.

The procedures for programming the operation of a tape controlled lathe are shown in Figures 18 and 19(1). They give an indication of the tasks required from the programmer, who replaces - so to speak - the planner and the operator. However, once a programme is completed and the final tape prepared, there is no need for repetition as in the case of - e.g. - a fully automatic cam operated machine which must be set up anew every time the production of a certain component is to be undertaken.

Although it is desirable to plan all manufacturing procedures to the last detail, there are instances in which this is either not possible or not desirable. For example, even allowing for the unlikely possibility that by the 1980's optimum cutting conditions will be known for every possible combination of tool and workpiece materials, for specified surface finish and tool life requirements, there remains the danger of variations occurring in the mechanical and manufacturing properties of these materials. In such cases the control equipment must be capable of adapting, during the operation, the machine settings in such a manner as to ensure that the desired workpiece qualities are obtained satisfactorily (adaptive control), and this requires further special knowledge on the part of those in charge of the machines and their control equipment.

Finally, machine tools cannot work reliably unless they are kept in a state of high efficiency during their working life. Emergency repairs of breakdowns, however good the repair squad, cause hold-ups in production because they usually occur at the most inopportune moments. Instead of providing for such emergency work by default, carefully worked out plans for regular inspection and maintenance have been introduced in many factories. However, the scheme will have to be further extended to include not only the prevention of functional breakdown but also maintaining performance quality, etc. In addition to the well known existing schemes for acceptance tests new schemes covering performance tests of mechanical, electrical and electronic equipment in accordance with predetermined time schedules will have to be developed on a large scale, and will have to be implemented by a staff of engineers who have not only the technical competence to deal with ordinary difficulties but also the ability to make decisions in unexpected situations.

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(1) From VDF News, No. 32, February, 1968.

Economic Efficiency

In order to be competitive, the manufacturing cost of the product must be kept low. This depends not only upon the labour cost, i.e. the productivity per man, but also upon the cost of purchasing and installing the machinery required and upon its utilization.

Cost of Machine Tools

If the accuracy of a machine tool is obtained by means of some separate control equipment, rather than being built into the machine structure at considerable cost (see pp. 54 and 56), machines can be acquired on the basis of the lowest degree of accuracy that is generally required and upgraded from case to case by suitable controls without the need for high overall cost levels or highly skilled operators. Accuracy is, however, only one factor in the cost of a machine. Versatility may be equally costly, especially because all available functions of a machine tool are rarely needed in all its applications. A means of overcoming this problem may be the use of "modular" design methods. These consist of sub-dividing the machine tool into relatively simple functional units which can be assembled, dismantled and re-arranged in different combinations if and when the need arises, similar to the well known transfer lines(1).

If each unit (spindle head, bed, carriage, etc.), is intended for a particular type of machining process, whether it is used in a more generally utilizable machine or a built-up special-purpose combination, there can usually be only one optimum design. This design ought to form the basis for the standard unit. Of course, each complete machine, which can be built from such standard units, must be so designed as to have an optimum range of applicability in the machine shop.

The design of standard units, "modules" must, therefore, satisfy the following conditions:

1. The alternative designs and combinations must cover the full range of requirements;
2. the performance must neither be above nor below the conditions laid down in the specification;
3. the connecting elements (joints, slideways, shaft centres, clutch or coupling arrangements, etc.), must be so designed as to ensure interchangeability.

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(1) F. Koenigsberger, Modular Design of Machine Tools, Proc. Int. Conf. Manufacturing Technology, A.S.T.M.E., 1967.

The ranges to be covered as far as dimensional, speed and power capacities are concerned, must be determined by careful study. Whilst the power range of spindle drives must be wide enough to cover the needs which may arise in the use of a certain type of machine tool, the power range of feed drive units can usually be much narrower, the ratio between feed power (feed drive) and cutting power (spindle drive) in most cases being so small that the wastage incurred in applying a larger feed drive unit than necessary for a smaller machine is not serious. Similarly, the differing cutting power conditions determine the stiffness requirements of structural elements whilst control units, gear change mechanisms, etc., can be identical for wider power ranges. The rational selection of structural sizes is usually dictated by the specified dimensional capacity of a machine, whilst due allowance must be made for functional requirements when determining the range of control devices which are to be made available.

This would of course involve a complete re-organisation in the approach to machine tool design and manufacture, so that instead of specializing on machine tool types, companies would concentrate on the design and manufacture of, e.g.

(i) Structural units;
(ii) units for aligning, locating and driving rotary elements (spindles) which may carry workpieces (turning operations) or cutting tools (drilling, boring, grinding or milling operations);
(iii) carriage units and drives with guiding and driving devices for rectilinear movements and for carrying cutting tools (turning, drilling or shaping) or workpieces (planning, milling, boring);
(iv) speed change devices for driving (ii) or (iii);
(v) measuring devices;
(vi) devices for manual or automatic control.

The latter two are perhaps the only fields where such specialization has been established, but even here co-ordination with machine tool designers and standardisation between different companies is still badly needed!

There is no reason against bringing under one standard specification the spindle drives for turning and milling machines, provided that their operating conditions are carefully studied and the "standard" units correctly applied in each case. Moreover, whilst different manufacturers of similar units or groups could use all their ingenuity to improve on their designs, the selection of ranges and steps, of basic dimensions, speeds and feeds, as well as the shapes and sizes of connecting elements (slideways, locating faces, spigots, driving shafts, couplings and clutches) would have to adhere to general standards. The use of preferred numbers for numerical values of dimensions, speeds, feeds, etc., would make possible the use of standard calculation charts, tables, computer programmes, etc., thus facilitating the work of all concerned.

If large quantities of components can be grouped together due to their production requiring a large number of technologically similar machine operations, the use of flow lines or machining centres(1) may be advantageous. However, as the times required for setting-up or tool changing are usually rather long, much greater use must be made of "pre-set" tools, the pre-setting in special tool holders being carried out in the tool room, whilst the machine is working on another job. In this manner the "non-productive" work of tool setting can be carried out whilst the machine is engaged on "productive" work. Finally, human errors and delays should be kept to a minimum by "automating", as far as possible, not only the manufacturing operations but also materials storage, handling, inspection and despatch.

Economic Plant Utilization

The greater the versatility of a machine tool the more easily it can be fitted into any part of a production process. On the other hand the more versatile such a machine the more difficult is its employment with a high factor of utilization in terms of available time, power, dimensional capacity, operational facilities and qualitative performance. High time utilization of a machine is achieved only if its rest periods are dictated by operational needs (planned maintenance, loading and unloading, inspection), and if these are - of course - kept as low as possible. Whilst the utilization problem may be less serious with low cost machinery it becomes of vital importance when expensive machines are needed for large quantity and high quality production.

---

(1) H.M. Lebrecht, The Machining Centre Concept, Proc. 8th Int. M.T.D.R.Conf., Manchester 1967.

It is necessary, therefore, to introduce shift work which must be so organised as to allow full productive activity, planned maintenance being arranged to take place - as far as possible - in between production shifts. Moreover, in order to utilize the full productive capacity of the machines their loading must be accurately pre-determined. The "System 24" concept(1) has shown an interesting way in directing work to machine units when they become available. This system is applied to relatively small size light alloy components, but the idea may be extended to more general application by using coding, classification and group technology methods for specifying not only workpiece characteristics and properties but also workpiece materials, machine tools, cutting tools, special fixtures, etc. Machine loadings, etc., can then be determined rapidly with the aid of a computer, thus eliminating errors and delays which may be caused by human limitations(2).

The utilization of machine capacity plays an important part in the consideration of optimum machine loading. This may in fact lead to a change in the long established designs of standard machine tools. For example, as a result of component statistics the high occurrence of turned components with relatively small length-to-diameter ratios and requiring chucking operations was demonstrated. If such components were machined on conventional lathes the available length capacity would certainly not be utilized. Consequently the development of the so-called short-bed lathes was advocated some 10 years ago by Dr. Moll who demonstrated the savings not only in cost of installation but also in space requirements when using either manually operated short-bed lathes or front operated semi-automatic lathes (Figure 20)(3).

The principles of group technology and part family manufacture which lead to optimum machine tool selection and installation affect also the specification on which the design and manufacture of general purpose machines must be based. They include - of course - considerations of size capacity, speed and feed values and ranges as well as space requirements and ease of installation. This applies especially to machines which are to be incorporated in flow lines for parts family manufacture.

---

(1) D.T.N. Williamson, System 24 - A New Concept in Manufacture, Proc. Int. M.T.D.R. Conf., Manchester, 1967.

(2) E.A. Haworth, Group Technology - Using the Opitz System, The Production Engineer, January 1968.

(3) From H. Moll, A User's Viewpoint on the Machine Tool of the Future, Proc., 4th Int. M.T.D.R. Conf., Manchester 1963.

3. Organisational and Human Problems

Whatever the technological and technical perfection within the manufacturing organisation, its final success depends upon the human element, the men and women who organise, manage and carry out the production effort. The time they spend on their work will become shorter as compared with the operating time of plant and equipment, draughting machines, computers, machine tools, etc. The importance and the level of their contribution will correspondingly grow.

The type of work required of them is rapidly changing, from the manipulation of pencil and paper, the operation of levers and hand wheels on machine tools and the interpretation of precision instrument readings towards the writing of design specifications and computer programmes, the control, supervision and maintenance of electronic equipment and the decision-making when unexpected difficulties arise which cannot be dealt with by the computer because they have not been foreseen by any programmer.

The quality, training and treatment of these men and women must differ greatly from that of the majority of those who work in today's factories. Their responsibility increases as their number falls. The education of such men and women can no longer be based merely on the teaching of manual crafts and skills and the solution of standard problems.

Those who are relieved of routine work must be enabled to use their initiative but if they are to be able and authorized to make decisions, they must also understand the fundamental principles of their subject, which must serve as a basis for their considerations.

Moreover, if and when a company employs such men these must be given not only the responsibility for analysing a problem but also the authority for putting its solution into practice and the satisfaction of judging its outcome. This is, however, possible only if petty restrictions and rules based on antiquated ideas are overthrown. The possibility of putting the job, the solution of a problem, first and petty arguments of "who does what", etc., second, are essential if high production efficiency is the aim.

In other words many so-called metal workers of the future will have tasks which today are considered of managerial character. The effective use of computers and similar equipment operating at ultra-high speeds will require the mutual understanding and full co-operation of all who carry out the function of management, design and planning as well as machine tool installation, control, operation, supervision and maintenance. The whole attitude of the metalworker must be geared towards this goal. But he must be enabled to face these tasks not only at the beginning but also during the progress of his career. For this reason the training facilities for those who are to start their professional life must be supplemented by means for continuous re-education, so that the men and women in industry can keep abreast with developments, the rate of which will certainly not be less in 1980 than it is today. This is a point which must not be left to chance but requires careful planning and the laying of a sound foundation at school level.

4. Education and Training

In view of the developments and needs which have been outlined under item 1 to 3 the training of the "metal worker" - in the widest possible sense - must satisfy the following quantitative and qualitative requirements:

(a) A relatively small number of manually highly skilled craftsmen, i.e. machine operators and fitters.

(b) A large number of "technicians" who combine technical skills with the understanding of mechanical, electrical and other engineering fundamentals and who are able to cope with the advanced routine work, including decision-making, of planners, programmers and equipment "supervisors" (rather than "operators").

(c) A considerable number of qualified engineers of "graduate" standard who are able to carry out thoroughly creative work in advancing design, planning, processing and operating methods. These people must be able either to correlate the results of work previously done by others with a view to applying them to the solution of their own problems or to dismiss outside experience and develop new ideas from first principles. From their ranks should also emerge the managers who must appreciate the full range of tasks covered and in addition have the human qualities which enable them to lead and co-ordinate the work of all from the point of view of obtaining optimum efficiency in the production organisation.

It must be stressed again that such education - at all levels - must be available not only to the schoolboy, the apprentice or the student but also to the man working in industry, throughout his life. "Ability to manage change - whether keeping up with developments in professions or retooling for new jobs - requires education to be available when needed. Access to education governs the pace at which new knowledge is absorbed, adjustments are made to new technologies, and solutions are reached to related social, political and economic problems(1)".

Skilled Craftsmen

In view of the wide application of automatic processes, these men will be needed only for special tasks when, for reasons of technical or economic necessity, automatic equipment cannot be used. This does not mean that their work need be of inferior quality, on the contrary they may be needed to make up for some shortcomings of the more advanced processes. As some of their work may not be of the planned and programmed nature, they may not be required to work regular hours but they must be prepared to act as and when needed. Their training should, therefore, give them not only the required craftsmanship but also the readiness to place the task entrusted to them above everything else, the trustworthiness, the pride in their craft and the appreciation of their responsibility.

Technicians

The men who are to prepare, build, install, operate and service the more or less automatic equipment in the factory must also be able to do a good craftsman's job - if and when required - but this must be backed by a thorough understanding of the material in their care. They may only have to start an automatic machine and then watch the dials from time to time, but when they must go into action and step in as soon as something does not proceed according to plan they must understand the problem and decide what to do. When, for example, modular units of machine tools (see pp. 59 and 61) are to be built up, the technician must select and connect the best arrangements and test their satisfactory combination. These men need, therefore, both technical training and technological tuition, which will enable them to tackle their tasks from the planning stage through the programming and preparation to the initiation and execution of the actual manufacturing operation.

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(1) Howard A. Matthews, Tomorrow is Now, American Education, June 1967.

Qualified Engineers

This is the group on which the continual industrial progress depends, the group which has to develop existing and devise new designs, materials and methods. Their education must be of the highest academic standard and must also make them appreciate the practical needs of their professional activities. Whilst the basic principles underlying today's approach towards evolving academic syllabuses may still be applicable, the contacts with industrial realities developed along the lines of academic-industrial co-operation before, during and - if necessary - after the academic training must be considerably extended.

Conclusion

In any organisation, however highly developed, there will always be a need for some workers who are not so highly skilled either as craftsmen or as technicians. This becomes particularly apparent when automatic machine tools are introduced before the handling of materials, the loading of the machines with raw materials or the transport of half-finished products from one machine to another are equally mechanized and automatically controlled. When the skilled men of technician standard must also carry out these less demanding almost menial tasks, they will feel bored and frustrated.

It can hardly be imagined that at any time this type of work will be completely eliminated. There are, however, in any community always those who, by aptitude or inclination, do not wish to carry heavy responsibility or to do highly skilled or creative work. These will no doubt have to fill the positions to which they are suited.

Nevertheless, it is important to recognize that, as far as industrial manpower is concerned there will be a change of emphasis and a shift of qualifications, skills and crafts.

The industrial army of the 1980's will have more officers (graduates and technicians) than N.C.O.'s (craftsmen) and private (labourers) and yet produce more than ever before. This will result in the technologically planned and economically needed higher production efficiency of the available manpower and with it in a higher standard of living.

APPENDIX

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  (b) Assembly
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Figure 20 Space Requirements for Lathes (from Moll)

Figure 1
METAL REMOVAL RATE
(Taken from E. Merchant)

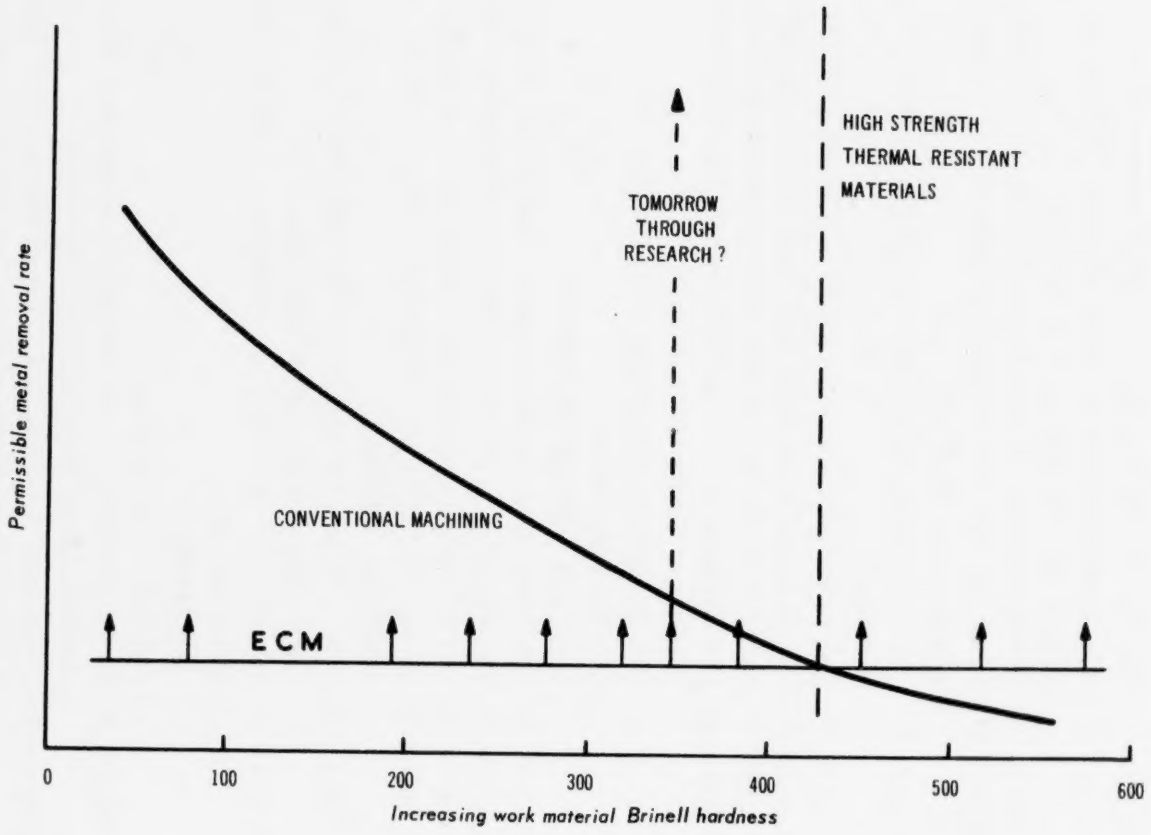


Figure 2

THE MANUFACTURING SYSTEM
(Taken from E. Merchant)

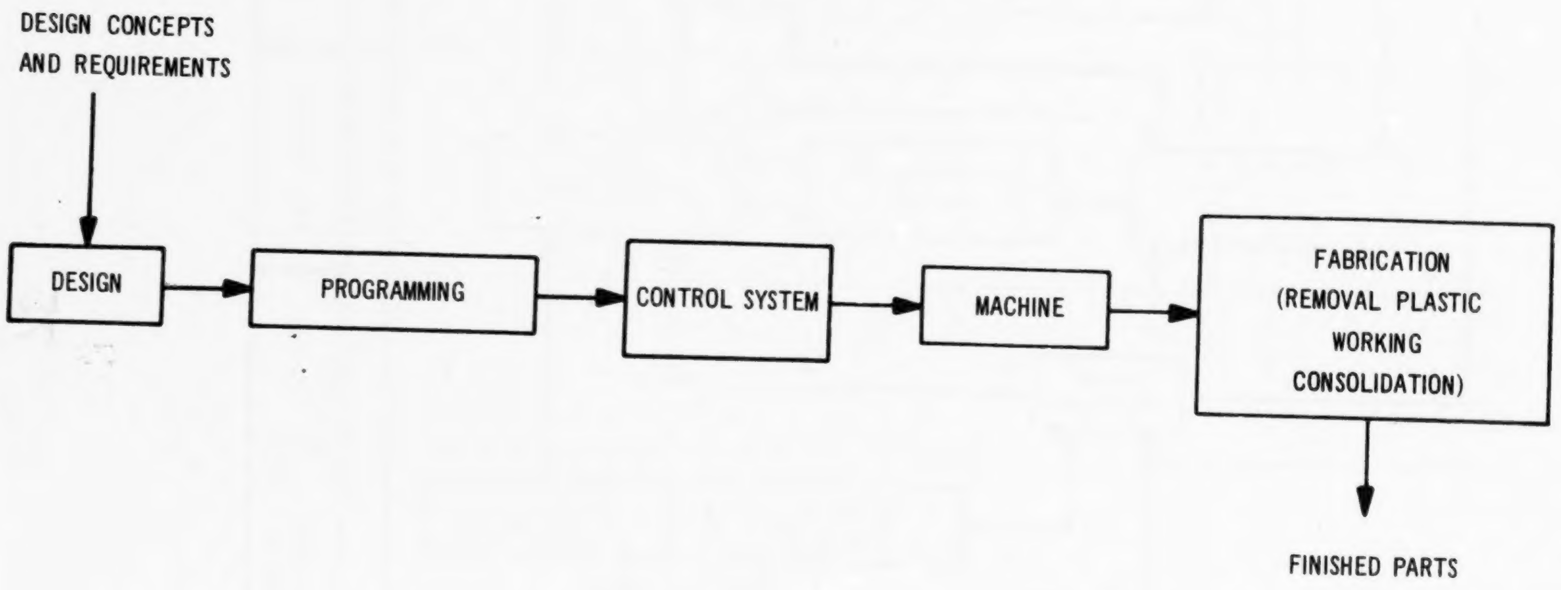

DESIGN CONCEPTS AND REQUIREMENTS
DESIGN
PROGRAMMING
CONTROL SYSTEM
MACHINE
FABRICATION (REMOVAL PLASTIC WORKING CONSOLIDATION)
FINISHED PARTS

Figure 3

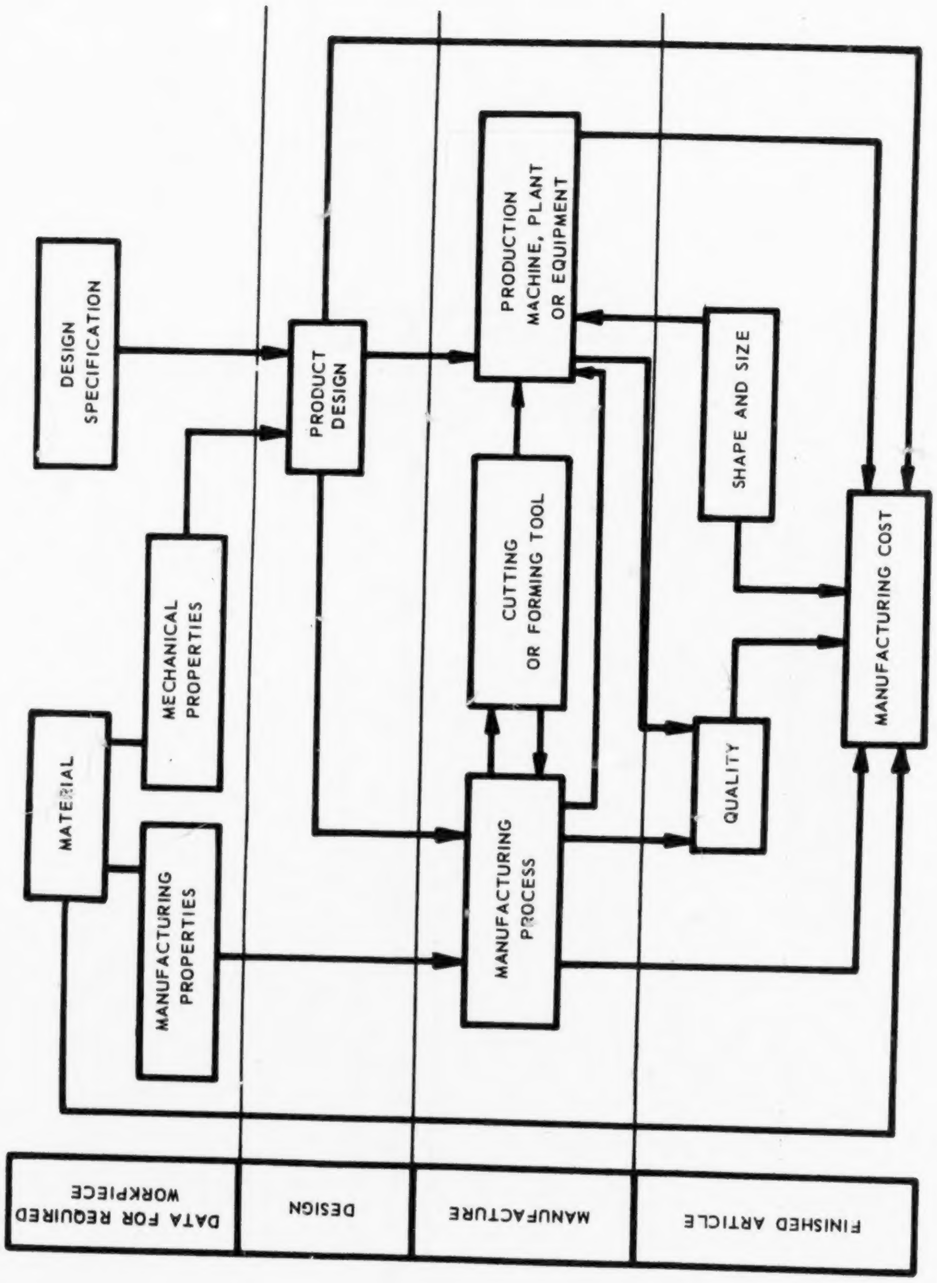

DATA FOR REQUIRED WORKPIECE
DESIGN
MANUFACTURE
FINISHED ARTICLE
MATERIAL
MECHANICAL PROPERTIES
MANUFACTURING PROPERTIES
DESIGN SPECIFICATION
PRODUCT DESIGN
MANUFACTURING PROCESS
CUTTING OR FORMING TOOL
PRODUCTION MACHINE, PLANT OR EQUIPMENT
QUALITY
SHAPE AND SIZE
MANUFACTURING COST

Figure 4

THE PRINCIPLE OF THE DYNAPAK MACHINE OF CONVAIR
(From W. Johnson, loc. cit.)

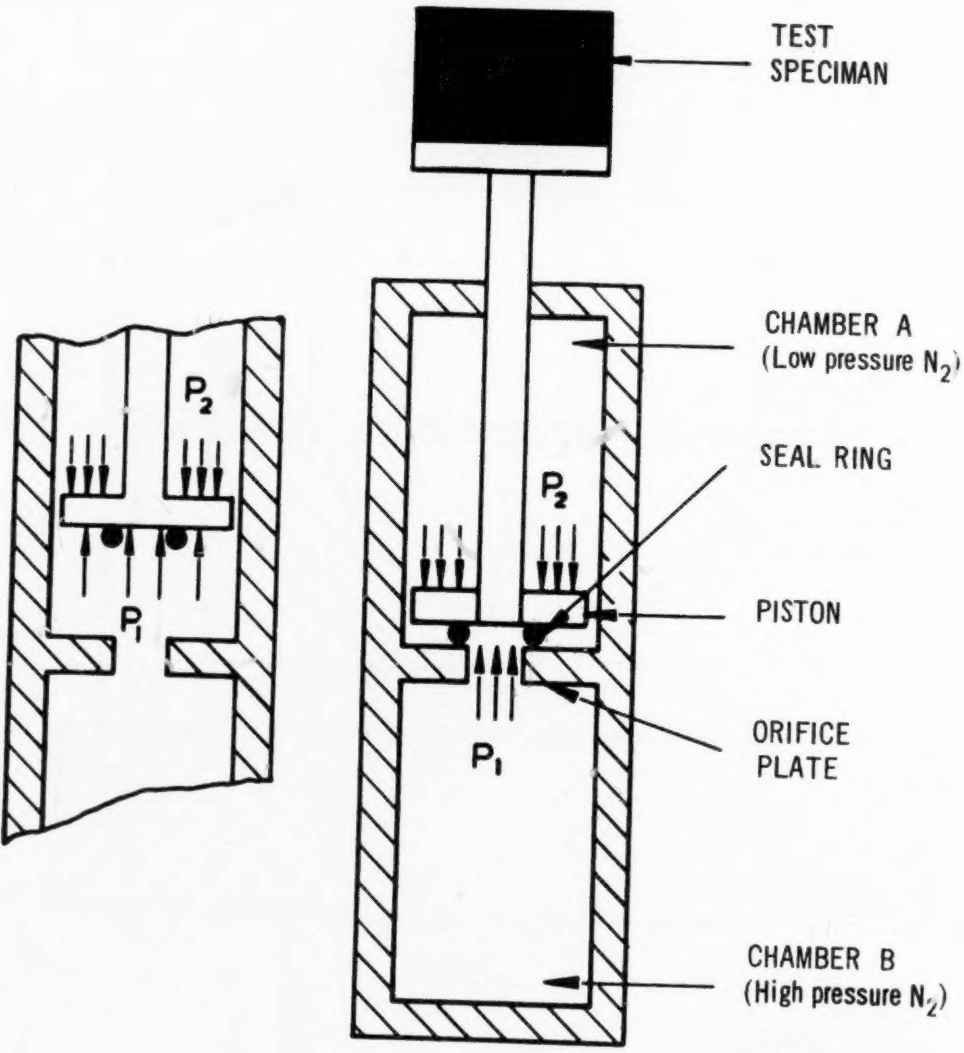

TEST SPECIMAN
CHAMBER A (Low pressure N_2)
SEAL RING
P_2
P_2
PISTON
P_1
P_1
ORIFICE PLATE
CHAMBER B (High pressure N_2)

Figure 5

A SET-UP FOR THE EXPLOSIVE DRAWING OF A HEMISPHERICAL SHELL

(From W. Johnson, loc. cit.)

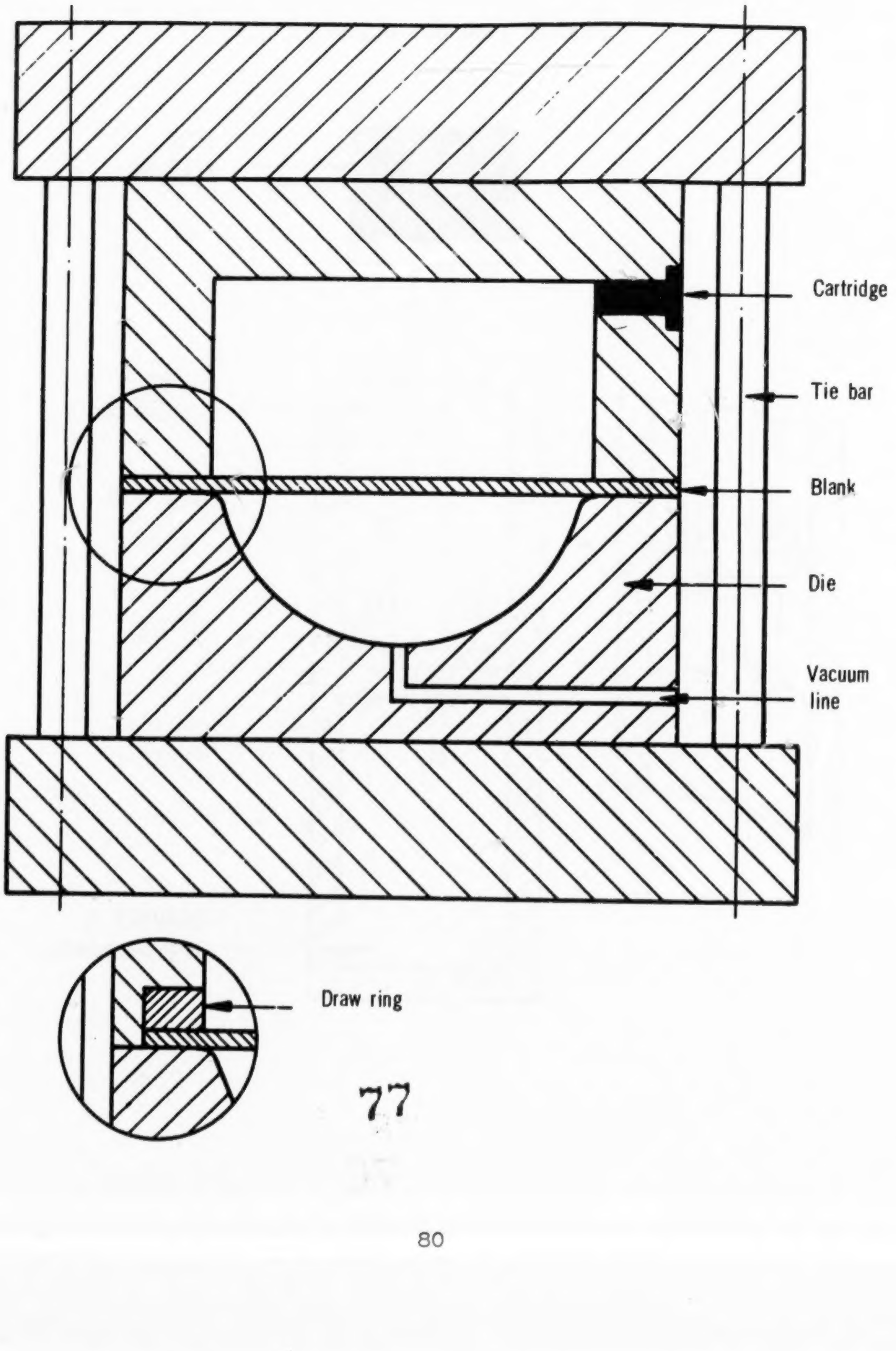
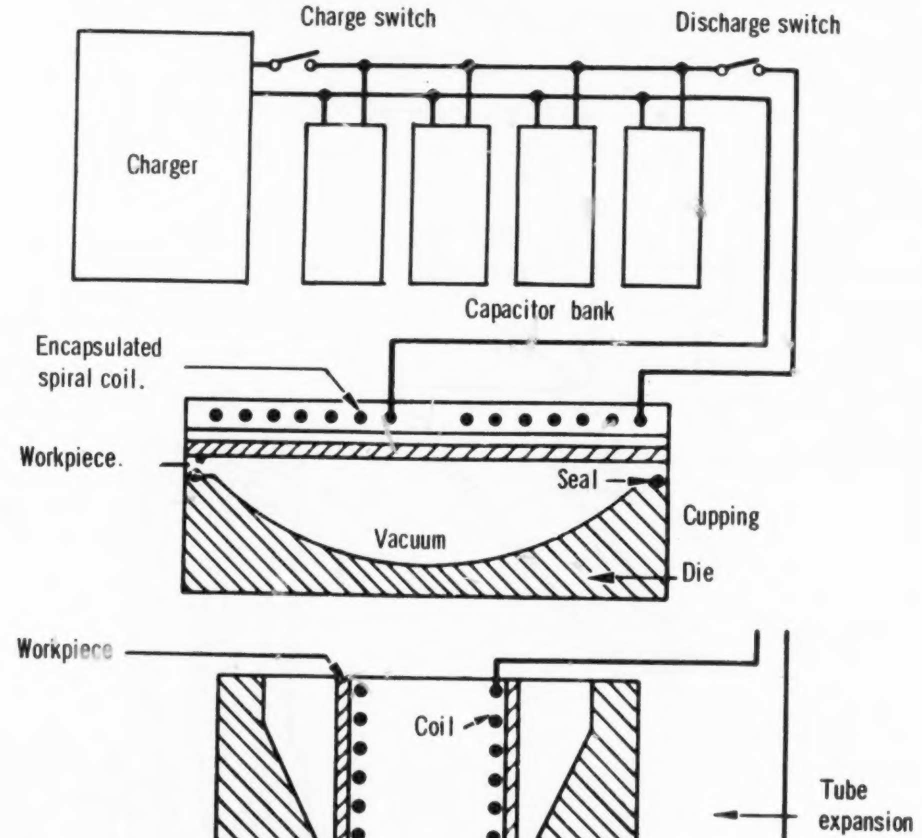

Cartridge
Tie bar
Blank
Die
Vacuum line
Draw ring

Figure 6

SCHEMATIC DIAGRAM ILLUSTRATING
THE PRINCIPLE OF THE ELECTROMAGNETIC FORMING PROCESS (EMF)
(Taken from E. Merchant loc. cit.)

a) Flat material deformed into the die.


Charge switch
Discharge switch
Charger
Capacitor bank
Encapsulated spiral coil.
Workpiece.
Seal
Cupping
Vacuum
Die
Workpiece
Coil
Tube expansion
Die

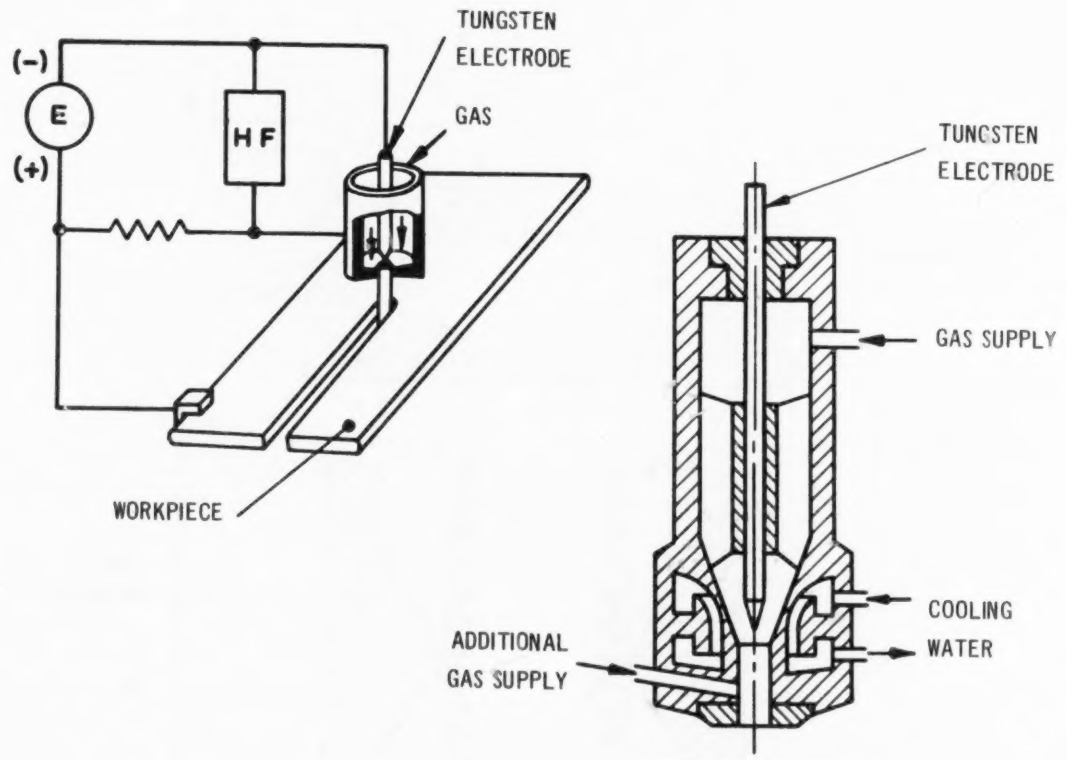
b) Tube expanded.

Figure 7

PRINCIPLE OF GENERATING A PLASMA JET

FROM OPITZ, AACHEN COLLOQUIUM, 1962

Professor F. Koenigsberger, Manchester



TUNGSTEN ELECTRODE
(-)
E
(+)
HF
GAS
WORKPIECE
TUNGSTEN ELECTRODE
GAS SUPPLY
COOLING WATER
ADDITIONAL GAS SUPPLY
DISSOCIATION ZONE
10,000 - 14,000° C

Figure 8

ELECTRON BEAM MACHINING

FROM OPITZ, AACHEN COLLOQUIUM, 1962

Professor F. Koenigsberger, Manchester

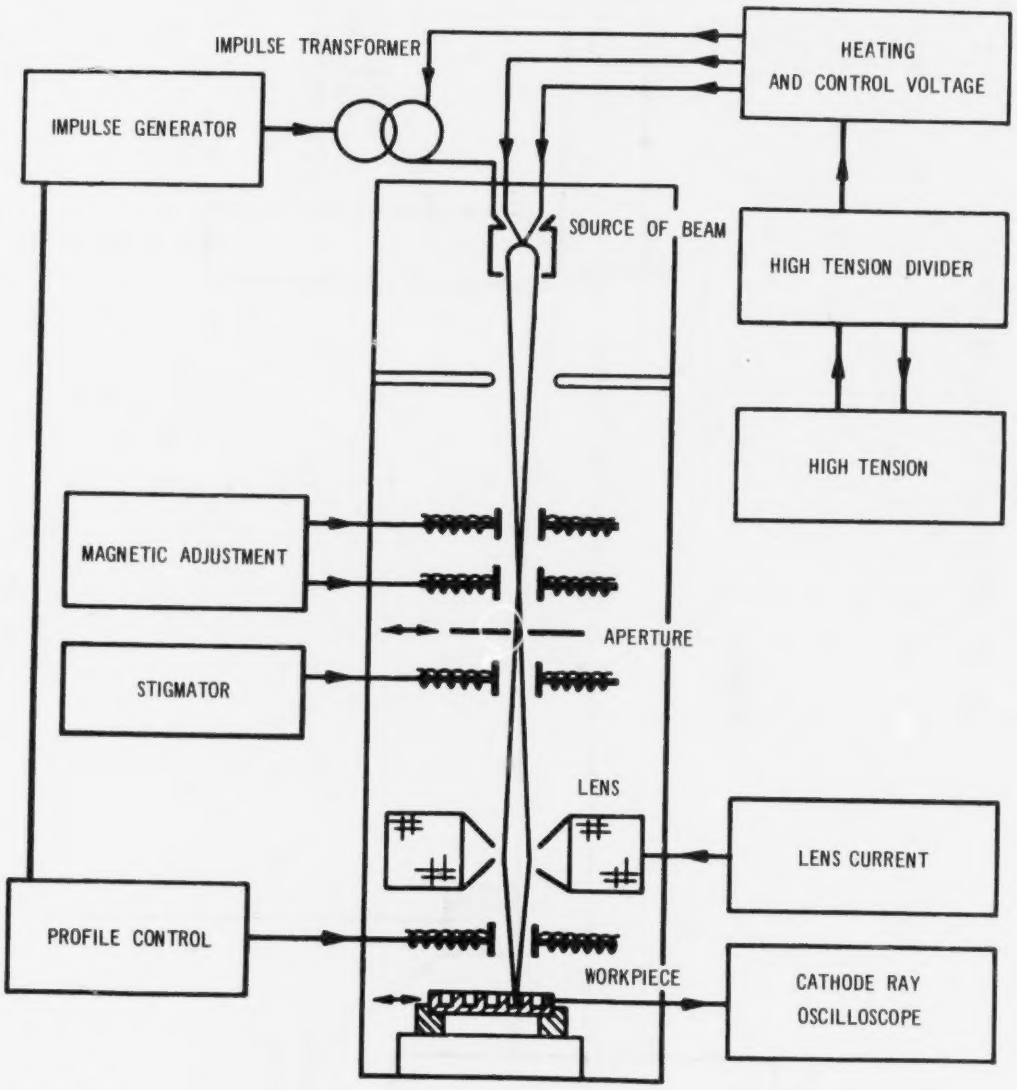

IMPULSE TRANSFORMER
HEATING AND CONTROL VOLTAGE
IMPULSE GENERATOR
SOURCE OF BEAM
HIGH TENSION DIVIDER
HIGH TENSION
MAGNETIC ADJUSTMENT
APERTURE
STIGMATOR
LENS
LENS CURRENT
PROFILE CONTROL
WORKPIECE
CATHODE RAY OSCILLOSCOPE

Figure 9

CIRCUIT DIAGRAM FOR HOT MACHINING

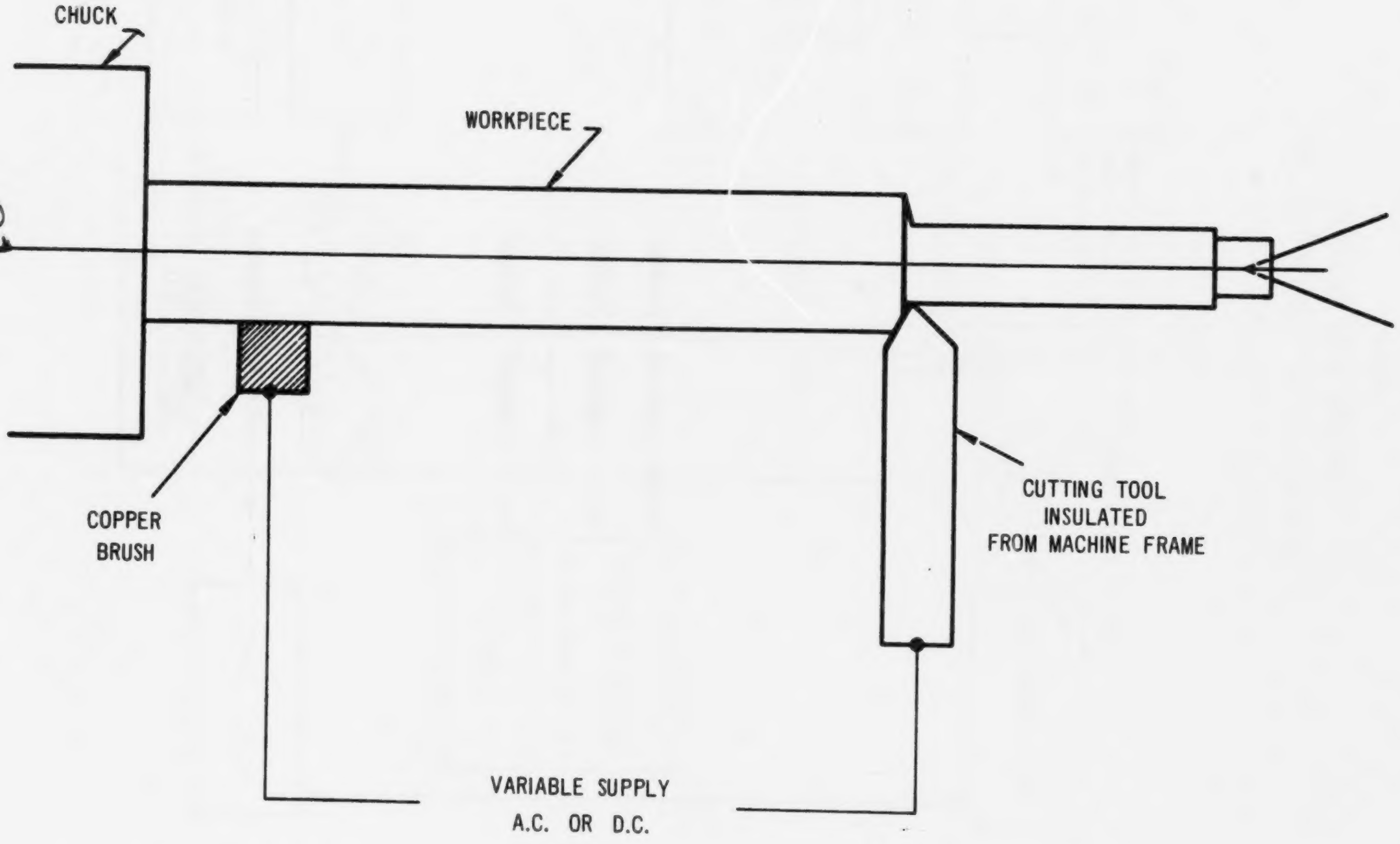
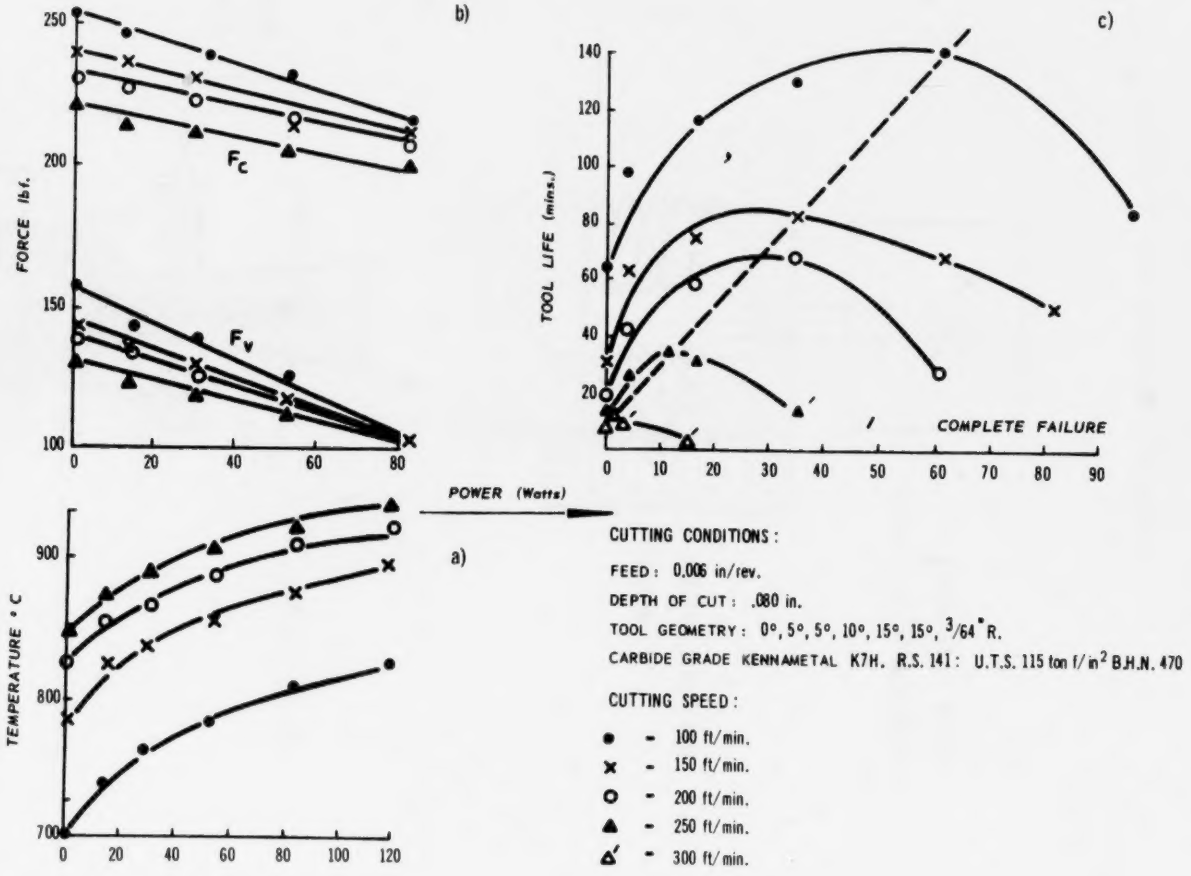

CHUCK
WORKPIECE
COPPER BRUSH
CUTTING TOOL INSULATED FROM MACHINE FRAME
VARIABLE SUPPLY A.C. OR D.C.

Figure 10

ELECTRICAL POWER DISSIPATED AT TOOL WORKPIECE CONTACT REGIONS AGAINST

a) Chip tool interface temperature b) Cutting force c) Tool life



CUTTING CONDITIONS:

FEED: 0.006 in/rev.

DEPTH OF CUT: .080 in.

TOOL GEOMETRY: 0°, 5°, 5°, 10°, 15°, 15°, 3/64" R.

CARBIDE GRADE KENNAMETAL K7H. R.S. 141: U.T.S. 115 ton f/in^2 B.H.N. 470

CUTTING SPEED:

● - 100 ft/min.
× - 150 ft/min.
○ - 200 ft/min.
▲ - 250 ft/min.
△′ - 300 ft/min.

Figure 11

PRINCIPLE OF ULTRASONIC MACHINING
FROM OPITZ, AACHEN COLLOQUIUM - 1962

Professor F. Koenigsberger, Manchester

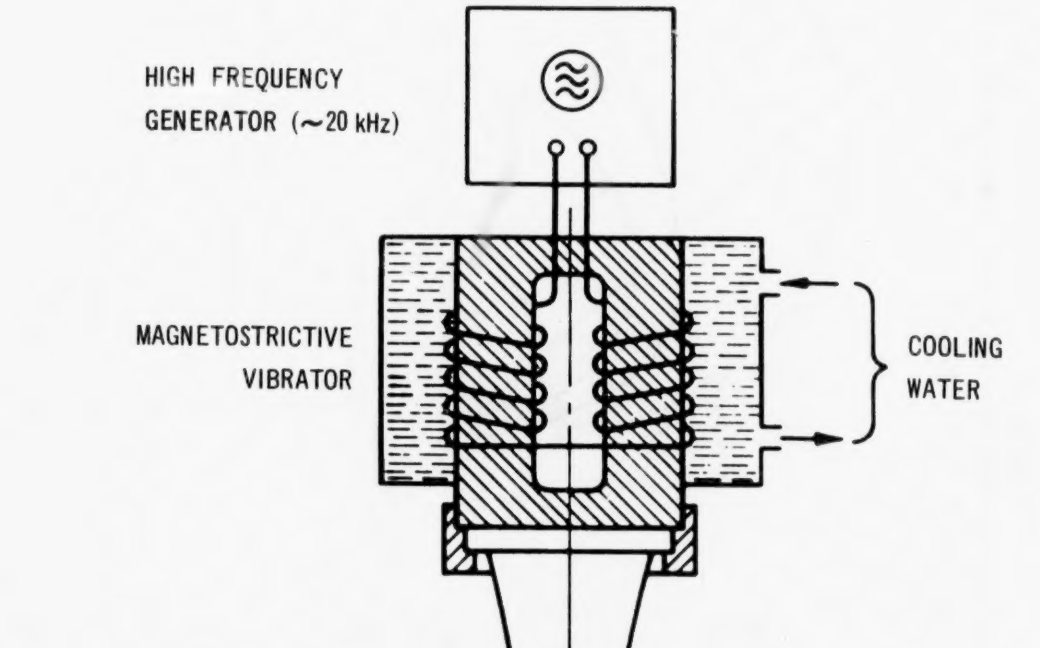

HIGH FREQUENCY
GENERATOR (~20 kHz)
MAGNETOSTRICTIVE
VIBRATOR
COOLING
WATER
BORING TRUNK
BORIUM CARBIDE
SUSPENSION
TOOL
WORKPIECE

Figure 12

PRINCIPLE OF SPARK EROSION MACHINING
FROM OPITZ, AACHEN COLLOQUIUM, 1962

Professor F. Koenigsberger, Manchester

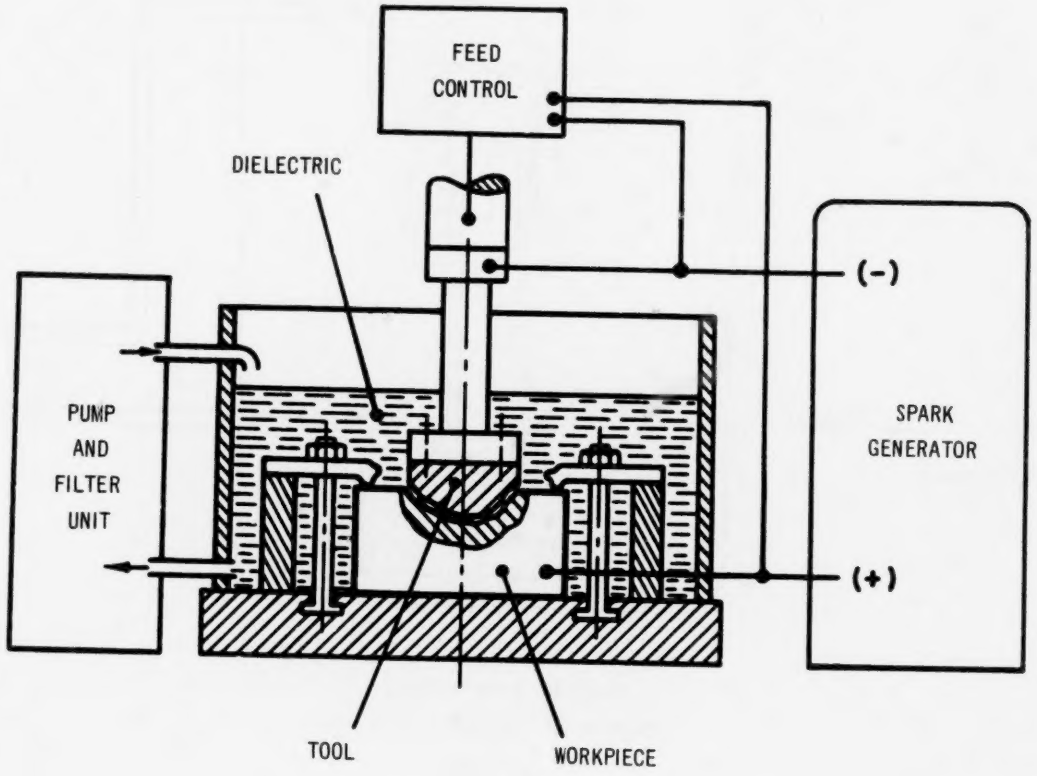

FEED
CONTROL
DIELECTRIC
(-)
(+)
PUMP
AND
FILTER
UNIT
SPARK
GENERATOR
TOOL
WORKPIECE

Figure 13

ELECTRO-CHEMICAL MACHINING

(Taken from A.E. de Barr)

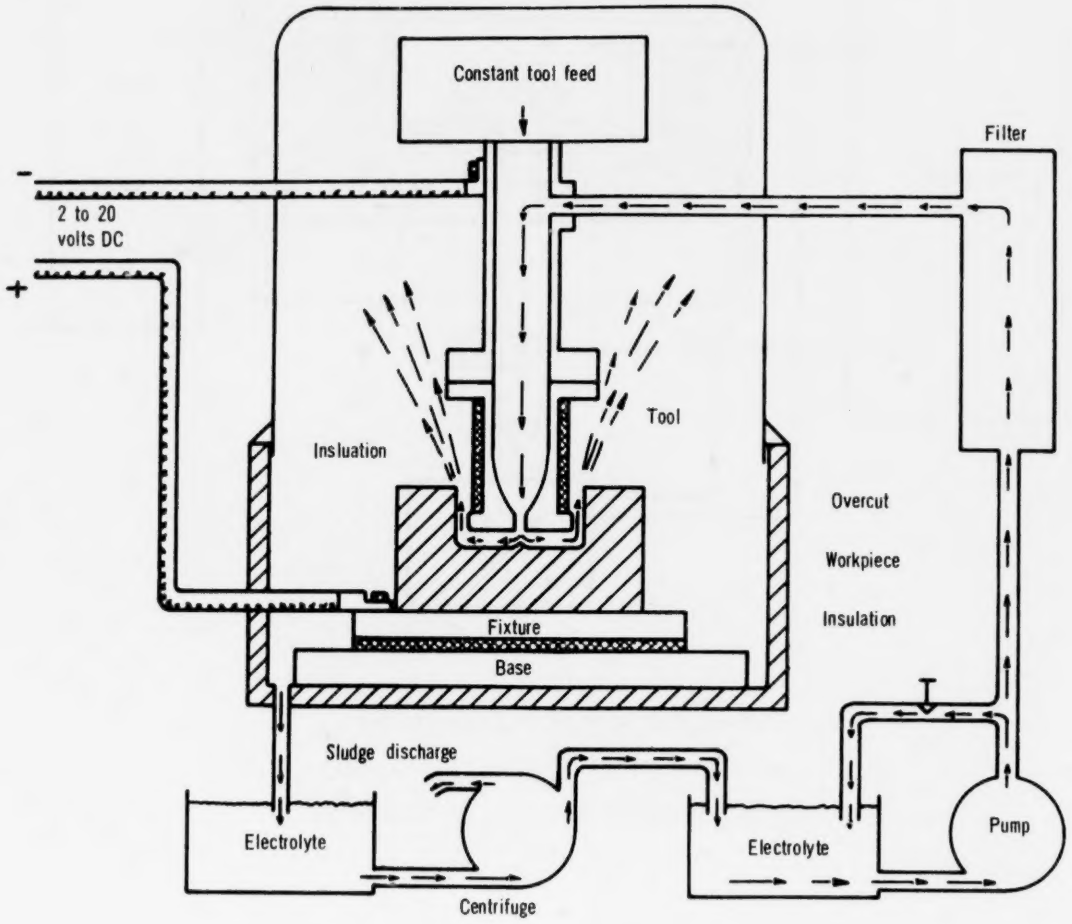

Constant tool feed
Filter
-
2 to 20
volts DC
+
Tool
Insluation
Overcut
Workpiece
Insulation
Fixture
Base
Sludge discharge
Electrolyte
Centrifuge
Electrolyte
Pump

Figure 14

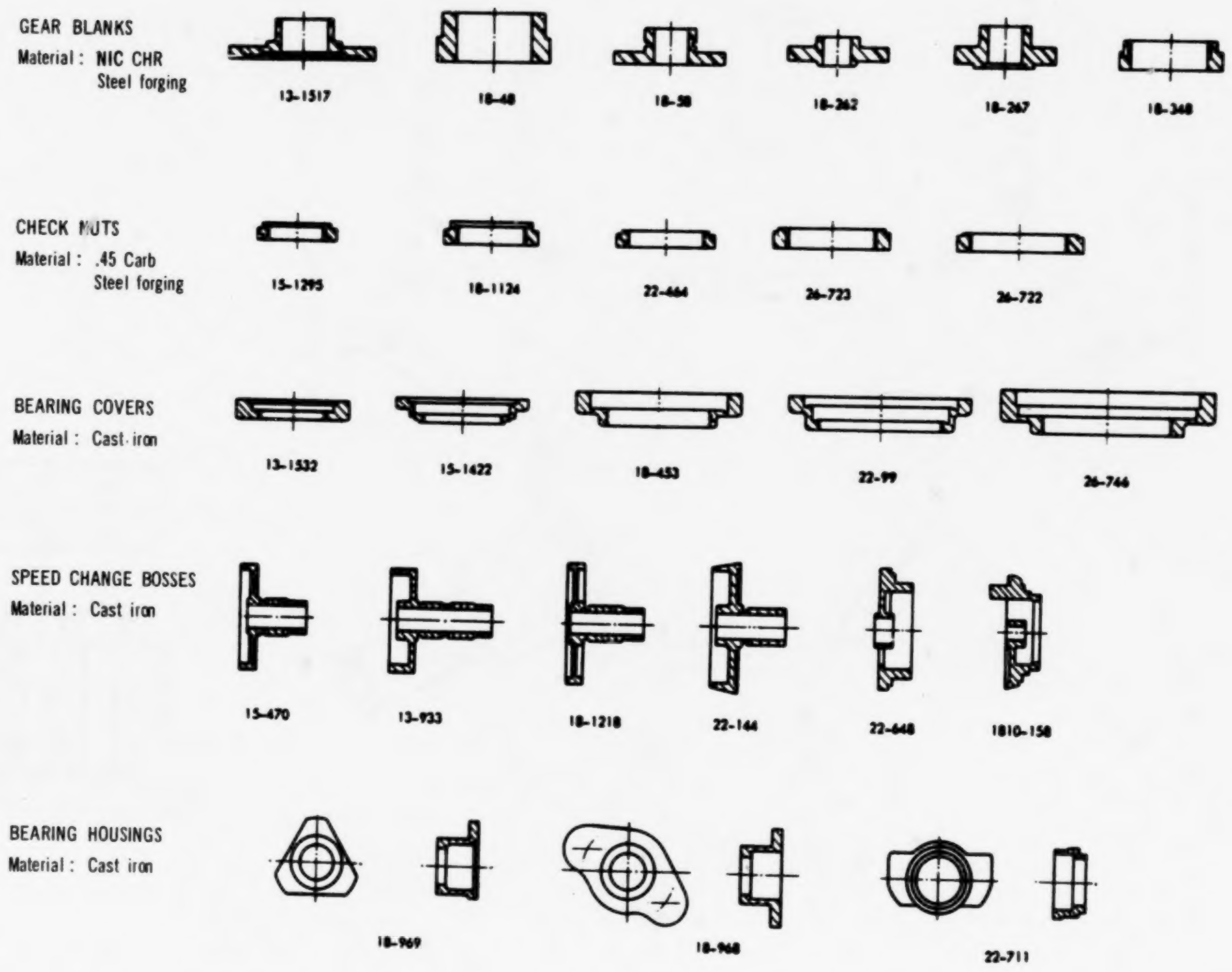
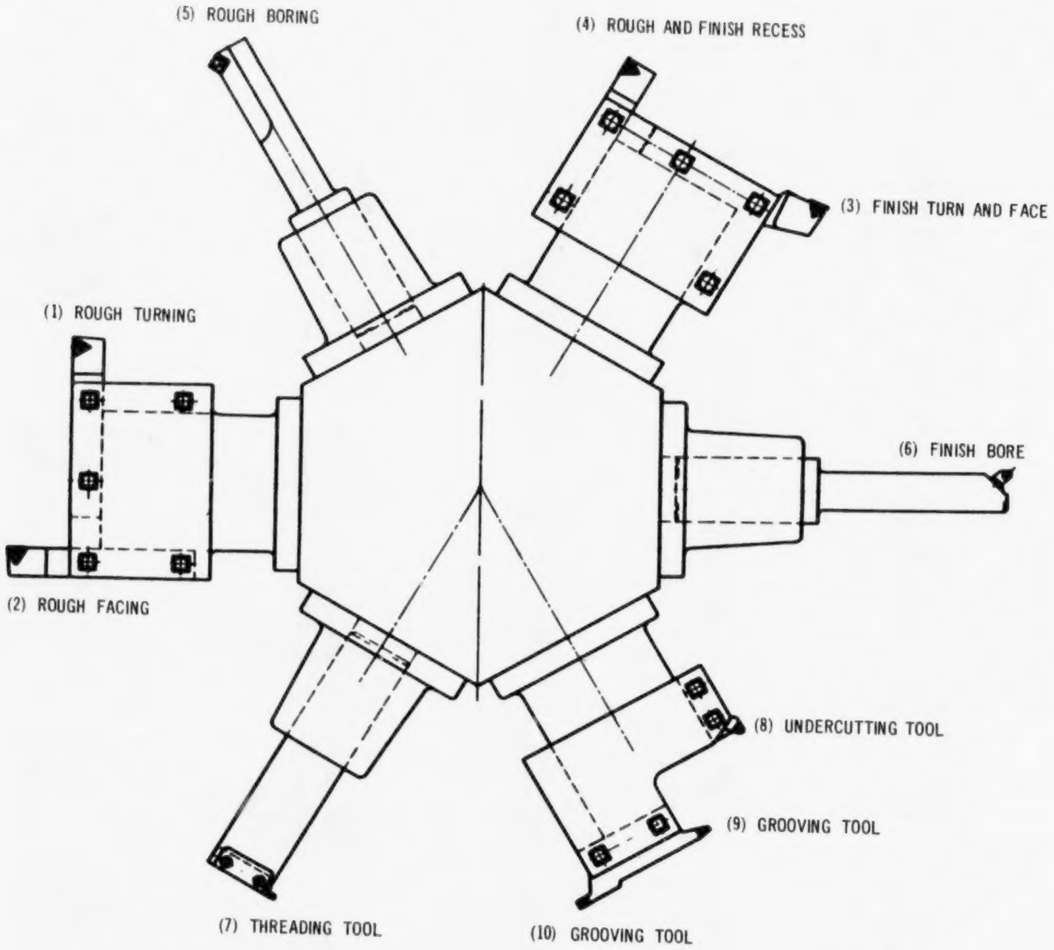

GEAR BLANKS
Material : NIC CHR
Steel forging
13-1517
18-48
18-58
18-262
18-267
18-348
CHECK NUTS
Material : .45 Carb
Steel forging
15-1295
18-1124
22-464
26-723
26-722
BEARING COVERS
Material : Cast iron
13-1532
15-1422
18-453
22-99
26-746
SPEED CHANGE BOSSES
Material : Cast iron
15-470
13-933
18-1218
22-144
22-648
1810-158
BEARING HOUSINGS
Material : Cast iron
18-969
18-968
22-711

Figure 15


(5) ROUGH BORING
(4) ROUGH AND FINISH RECESS
(3) FINISH TURN AND FACE
(1) ROUGH TURNING
(6) FINISH BORE
(2) ROUGH FACING
(8) UNDERCUTTING TOOL
(9) GROOVING TOOL
(7) THREADING TOOL
(10) GROOVING TOOL

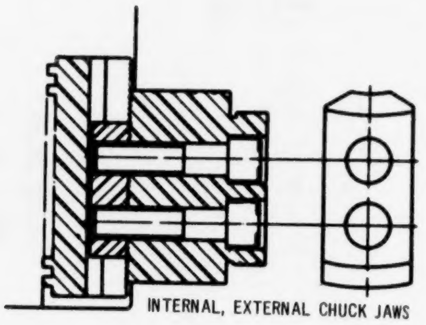

INTERNAL, EXTERNAL CHUCK JAWS

Figure 16

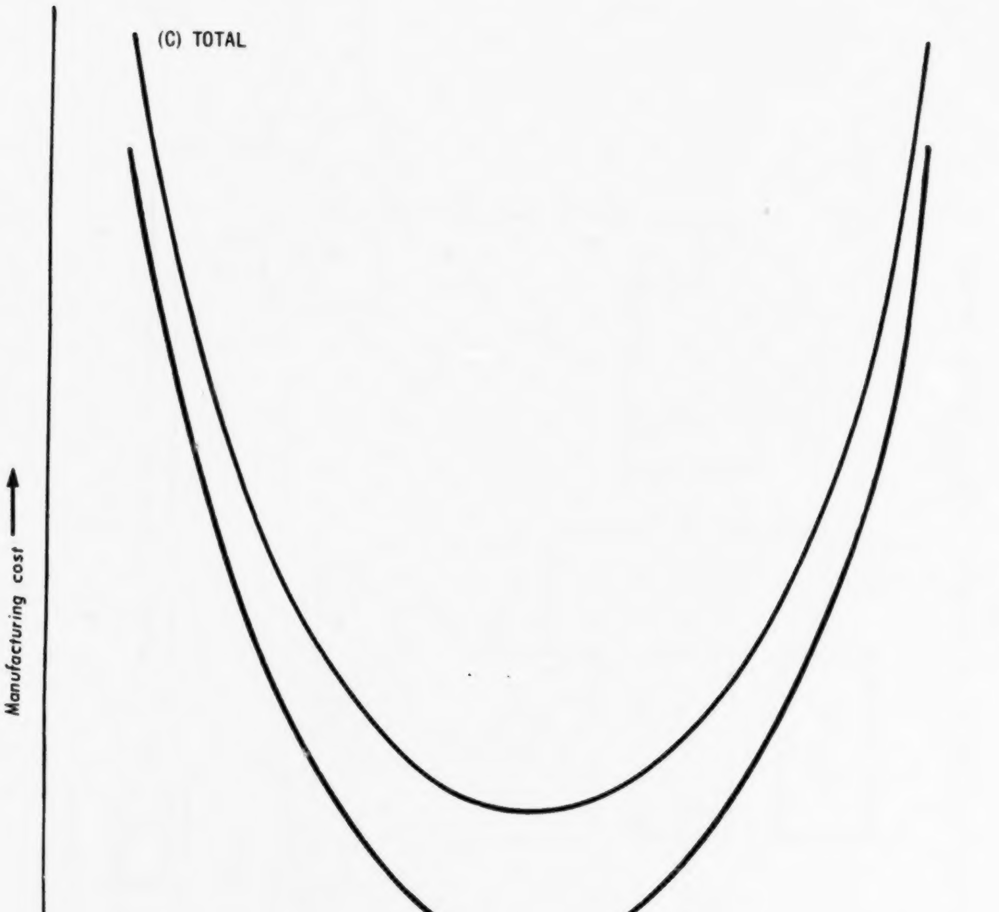

(C) TOTAL
Manufacturing cost
(A) MACHINING
(B) ASSEMBLY
Degree of accuracy

Figure 17

BLOCK DIAGRAM OF AUTOMATIC ALIGNMENT ERROR CORRECTION SYSTEM

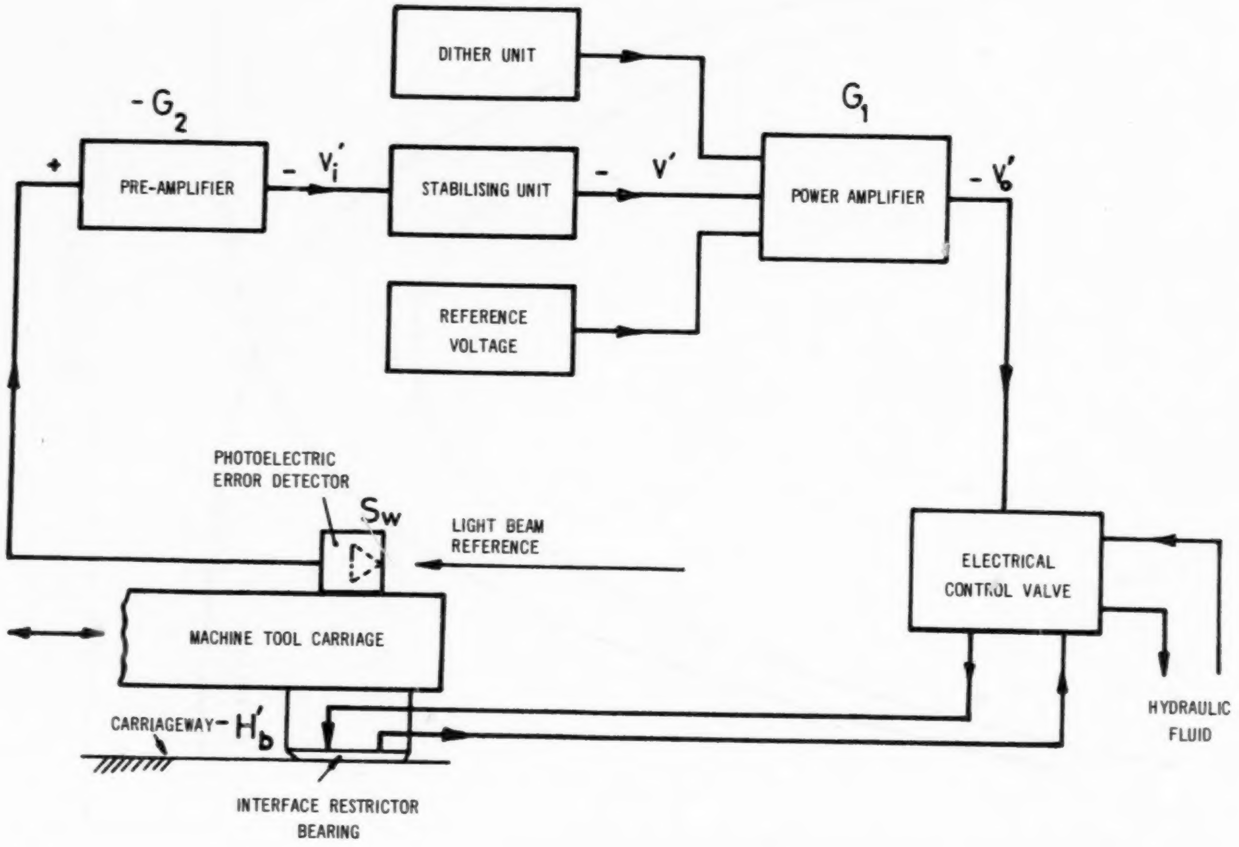

DITHER UNIT
$-G_2$
PRE-AMPLIFIER
+
$- V_i'$
STABILISING UNIT
$- V'$
G_1
POWER AMPLIFIER
$- V_o'$
REFERENCE VOLTAGE
PHOTOELECTRIC ERROR DETECTOR
S_w
LIGHT BEAM REFERENCE
MACHINE TOOL CARRIAGE
ELECTRICAL CONTROL VALVE
CARRIAGEWAY
$- H_b'$
INTERFACE RESTRICTOR BEARING
HYDRAULIC FLUID

Figure 18

PROGRAMME PREPARATION FROM FINISHED PART DRAWING TO PUNCHED TAPE

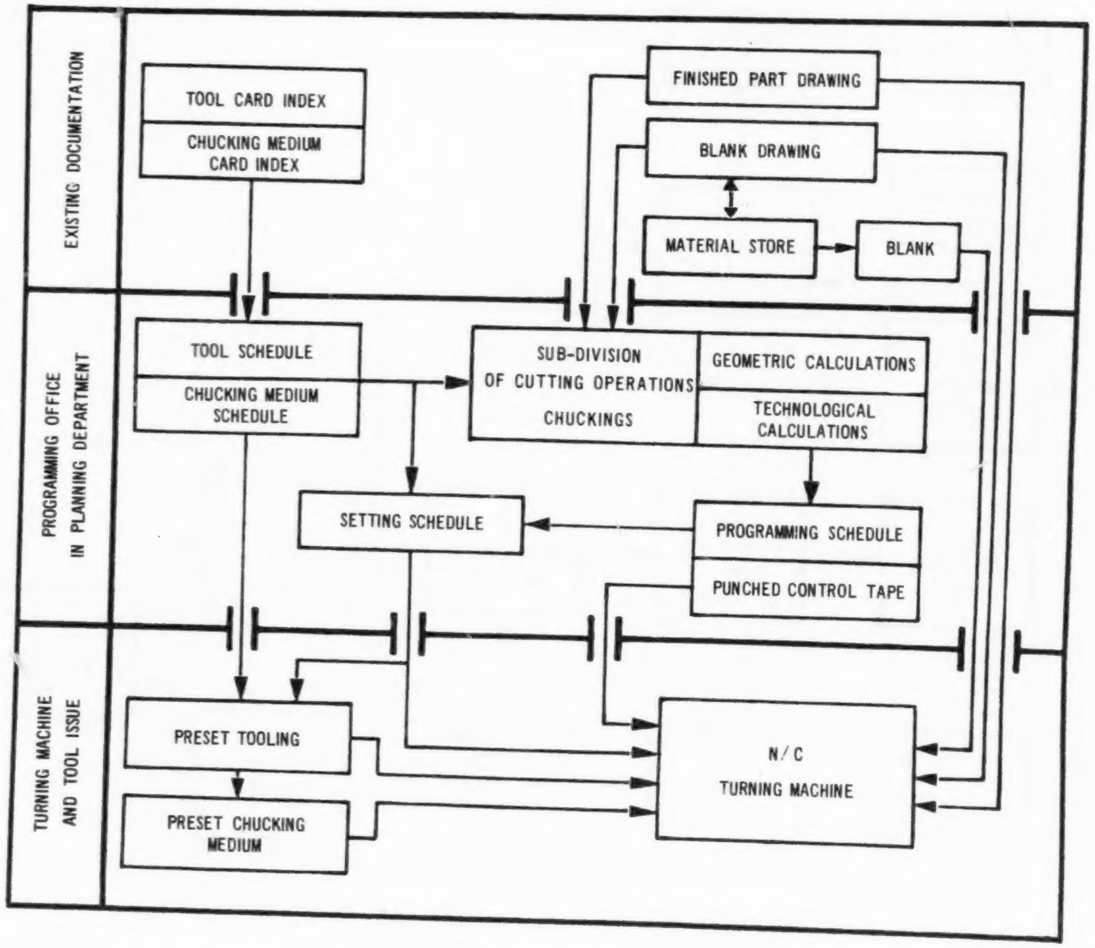

EXISTING DOCUMENTATION
PROGRAMMING OFFICE IN PLANNING DEPARTMENT
TURNING MACHINE AND TOOL ISSUE
TOOL CARD INDEX
CHUCKING MEDIUM CARD INDEX
FINISHED PART DRAWING
BLANK DRAWING
MATERIAL STORE
BLANK
TOOL SCHEDULE
CHUCKING MEDIUM SCHEDULE
SUB-DIVISION OF CUTTING OPERATIONS
CHUCKINGS
GEOMETRIC CALCULATIONS
TECHNOLOGICAL CALCULATIONS
SETTING SCHEDULE
PROGRAMMING SCHEDULE
PUNCHED CONTROL TAPE
PRESET TOOLING
PRESET CHUCKING MEDIUM
N/C TURNING MACHINE

Figure 19

PROCESSING THE VARIOUS ADDRESSES NECESSARY FOR THE PUNCHED TAPE

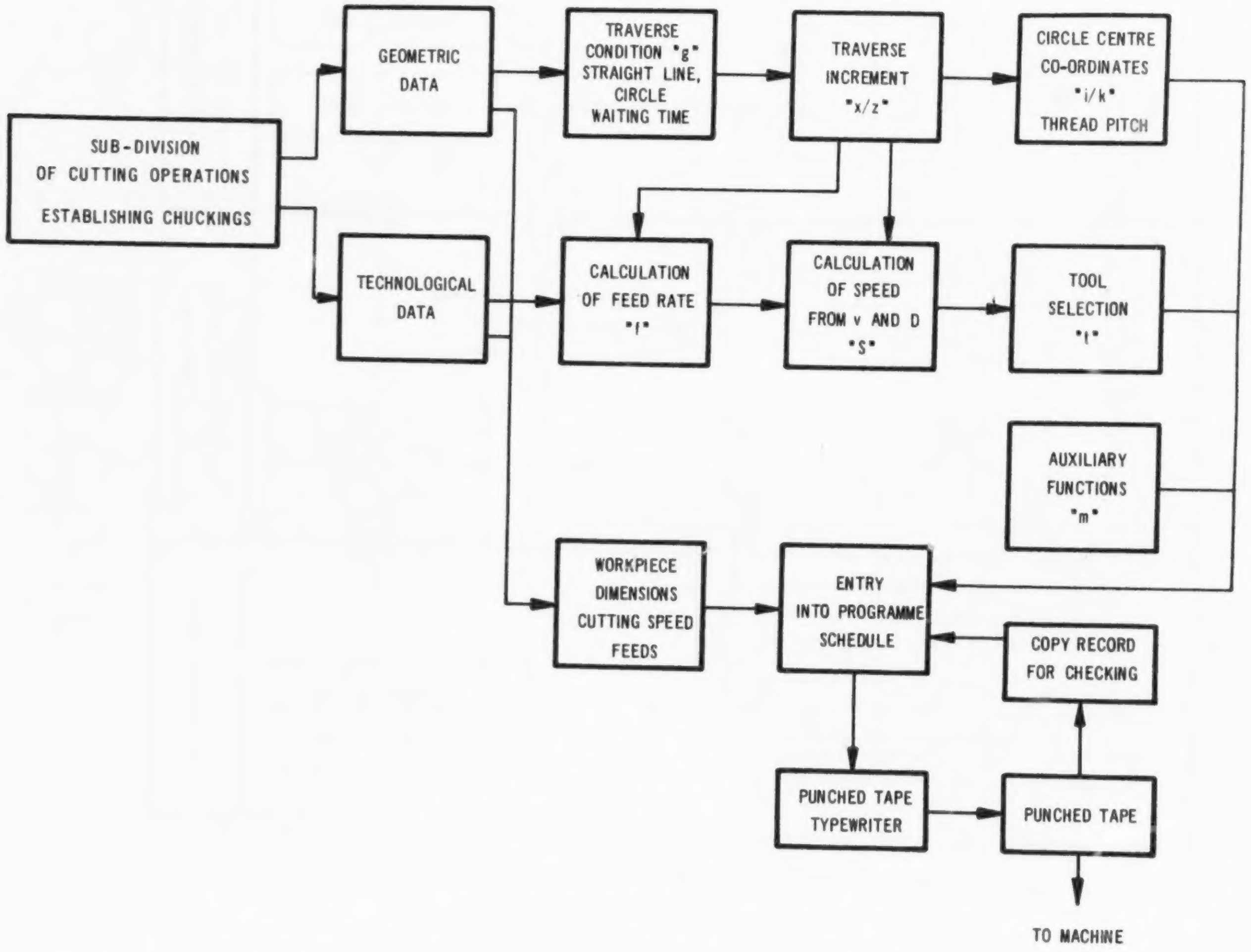
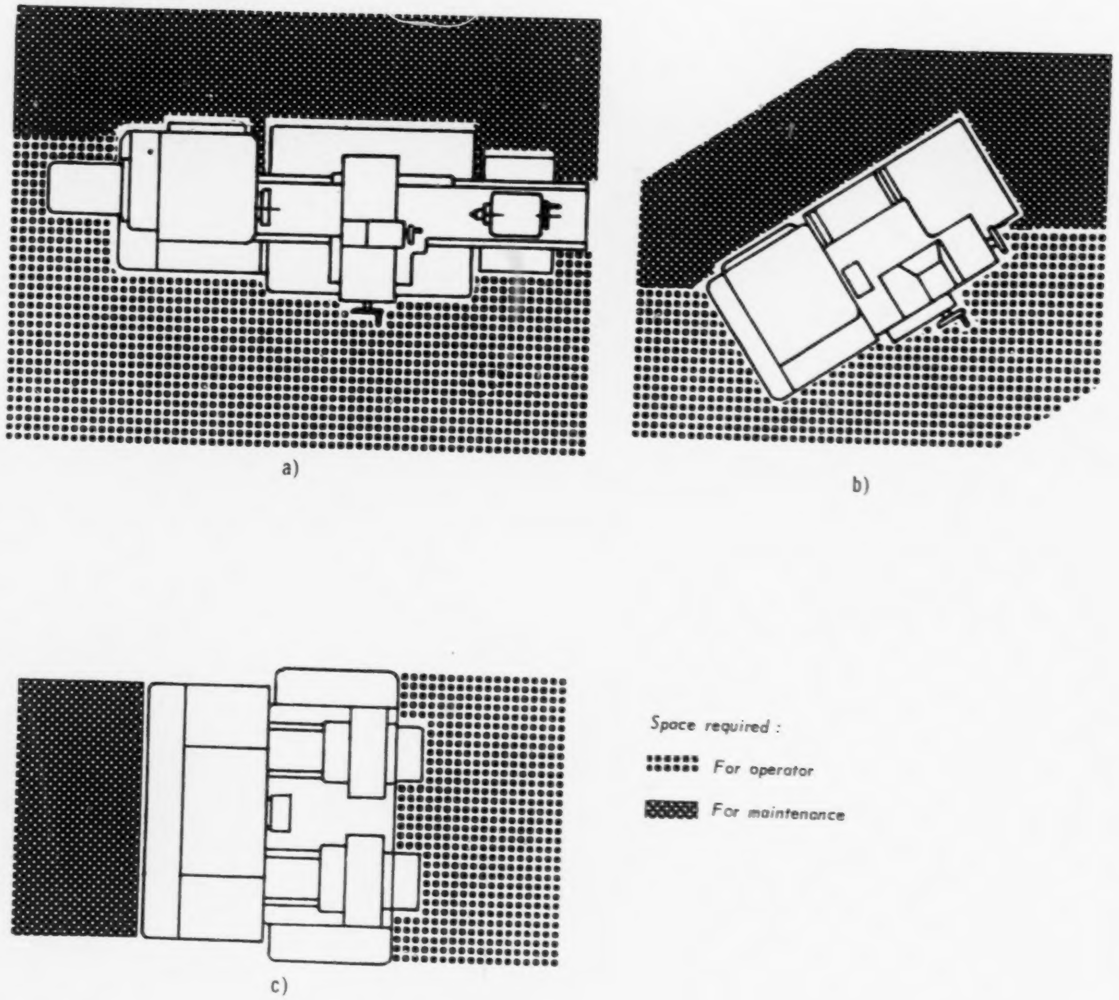

SUB-DIVISION
OF CUTTING OPERATIONS
ESTABLISHING CHUCKINGS
GEOMETRIC DATA
TECHNOLOGICAL DATA
TRAVERSE CONDITION "g" STRAIGHT LINE, CIRCLE WAITING TIME
TRAVERSE INCREMENT "x/z"
CIRCLE CENTRE CO-ORDINATES "i/k" THREAD PITCH
CALCULATION OF FEED RATE "f"
CALCULATION OF SPEED FROM v AND D "S"
TOOL SELECTION "t"
AUXILIARY FUNCTIONS "m"
WORKPIECE DIMENSIONS CUTTING SPEED FEEDS
ENTRY INTO PROGRAMME SCHEDULE
COPY RECORD FOR CHECKING
PUNCHED TAPE TYPEWRITER
PUNCHED TAPE
TO MACHINE

Figure 20



a)

b)

c)

Space required :
▦ For operator
▩ For maintenance

TRENDS IN THE MACHINE TOOL AND AUTOMOBILE INDUSTRIES

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Introduction

Forecasts have a tendency to become obsolete very soon. After only a couple of years, real developments have taken a different turn from that foreseen. The longer the period for which the forecasts are made, the greater the mistakes. It is intended in this report to give a forecast for the 1970's, i.e. 12 years from now. Twelve years is not a very long period. Going back twelve years brings us only to 1956.

You are not very impressed with developments since 1956? You don't feel that very much has happened? But to take just one example, we should remember that the entire space programme has been developed in this short span of time. The first satellite was launched only in 1957.

Apart from this remarkable progress much has also happened in other fields. Developments in the field of electronics do not look as remarkable as the space programme itself. Yet they are a precondition for the space projects. Conventional radio tubes have been replaced by transistors, which have been progressively reduced in size. Electronic equipment which previously needed a whole room to house it can now be condensed into a desk model. The reduction in weight is particularly important. Here the development over the last 12 years has been remarkable. I am convinced that developments in this field in the next 12 years will be as fascinating.

This report will attempt to understand the developments within certain sectors of the metal - and engineering industry - the machine tool industry and the automobile industry. The first problem encountered when making such a prognosis is the evaluation of the importance of different factors. One has to decide whether to make a conditioned or a non-conditioned prognosis. In a non-conditioned prognosis, external factors are not taken into account because they are impossible to foresee or because we choose not to take them into account for some other reason. A conditioned prognosis on the other hand tries to take account of external factors and their effect on developments.

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Even if you try hard to make one, you can never say for sure that it is really a conditioned or non-conditioned prognosis that you have made. You will only know this after a certain time has elapsed.

The choice of the parameters for the prognosis must depend to a great extent on intuition, i.e. you will have to pick the ones you think will have some significance for the prognosis. Such external factors as economic cycles and crises in the international monetary system are also left out of consideration, even though they are most important and might have catastrophic consequences for the prognosis. It is not possible to be exact at all in any speculations about these external factors, and it would therefore be better to give up any attempt to forecast them.

On the basis of the "historic" development, I have instead decided to discuss what might happen in the case of three factors: materials, products and administration, and on the basis of these factors I shall try to guess what the situation will be like in 1980.

Materials

The development of materials will influence the structure of the engineering industry. A change from conventional materials to new materials would revolutionize engineering. At present it is estimated that around 90 per cent of all construction materials consist of iron and steel(1).

In 1966 the world consumption of iron was 470 million tons. This figure will rise to nearly 900 million tons in 1980, if we are to believe studies that have been made. But although world iron consumption may be almost doubled, its relative share of total consumption will decrease. New materials, first of all plastics, will successively take its place. The total consumption of metal raw materials in 1966 was 487 million tons compared with the consumption of synthetic polymers of 25.5 million tons. In 1980 it is expected that the total consumption of plastics will be 105 million tons. Dr. Gerritsen expects that in 1983 the volume of synthetic materials consumed will be as large as that of iron(2). The consumption of plastics will increase 560 per cent in the next twelve years as compared with 91 per cent for iron.

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(1) R. Houwink, Kunststoffe, Edition 56 (1966), Section 8, page 597.
(2) J.C. Gerritsen, Plastica, Edition 14 (1961), No. 1,2,3 and 4.

However, there is no reason to believe that plastics will replace metals. It is more likely that plastics and polymers will be used in other areas and for new products which will be developed during the coming decade. A great number of today's products will be refined, some will disappear and new products will be created. The existing plastics have a great advantage over metals as they are more adaptable, but they lack durability and solidity. However, development towards plastics with new qualities is very rapid, and their use as construction materials will certainly increase.

CONSUMPTION OF MATERIALS
(millions of tons)

	1966	1980	Percentage changes
Iron	470.0	900.0	+ 92 %
Aluminium	7.7	32.0	+ 316 %
Copper, Zinc, etc.	9.7	16.4	+ 69 %
TOTAL METALS	487.4	948.4	+ 95 %
Plastic material	16.0	105.0	+ 556 %
Synthetic rubber	3.9	11.5	+ 195 %
Synthetic fibres	5.6	13.0	+ 132 %
TOTAL SYNTHETIC POLYMERS	25.5	129.5	+ 408 %
Natural rubber	2.2	2.6	+ 18 %
Natural fibres	19.0	30.3	+ 59 %
TOTAL NATURAL POLYMERS	21.2	32.9	+ 55 %
TOTAL CONSTRUCTION MATERIAL	534.1	1,110.8	+ 108 %

Source: R. Houwink, Kunststoffe, No. 8 (1966), page 597.

Shaping and Machining

Behind every calculation of a product there are several factors: cost, design and choice of material. The product can be shaped for example through cutting, compacting, clipping or stamping. Every product and the length of the series of production demands a different production technique. At present a great deal of research into shaping is being carried out. Considerable gains can be made here. A reduction of one per cent of the effective cutting time in the cutting processes of the Swedish engineering industry would save the cost of 200 workers per year(1). It has been estimated that the total cost of cutting, excluding materials, is over one billion kronor a year. A saving of ten per cent would mean, in other words, 100 million Sw. Kronor. The industry is specially interested in reducing the times for manual operations adjustment and distribution as it is estimated that the machine and the machine tool are operating only 50 per cent of the time. Full utilization is becoming more and more important. The cutting processes have often been called irrational or a necessary evil. This is because they take too much time and valuable material. Under cutting processes (machining) should be understood a large number of methods in a shaping or designing process which entail separation of material: turning, milling, drilling, planing, threading, grinding, etc.

Some 20 years ago it was felt that cutting processes would diminish and that casting, clipping and plastic shaping would take over. Developments have now taken a turn in this direction and will continue to do so. Many standard products have been redesigned and now have moulded details, for instance electric plugs. But at the same time new details are needed, often in limited numbers. This happened at A.S.E.A. a few years ago. New designs reduced the machining time for drilling machines and milling machines, but at the same time a new production line of operating tools for atomic energy plants needed machining. It is well known that advanced plastic and clipping methods require large series to be economic.

One of the materials which seems likely to play a greater role in the future is aluminium (see Table 1). It is always tempting to shape aluminium constructions by cutting. Cutting is in fact far from being written off. The advent of numerical machines also means that machining will be given greater prominence(2). For the time being it is therefore obvious that industry will have to continue with present cutting processes, first of all in mixed production, no matter what people think of the method as such. During the last century, tools made of common carbon steel were used in the cutting processes. The process was time-consuming. In 1880 a simple detail of the turning operation of an axle made from non-alloy construction steel took about 215 minutes. The time taken today for a similar job is 4 minutes(3). The successive

(1) Verkstäderna, 1964, page 5.
(2) Verkstäderna, 1966, page 415.
(3) Industria, 1965, page 86.

stages in this development have been carbon steel, high speed steel, tipped tools and ceramic cutting. Tools made of carbon steel have practically disappeared. Ever since the first high-speed steel tools were introduced, the engineers understood that the metal carbides with a low fusibility, e.g. tungsten carbide, were very hard, heat proof and hard wearing, which are three very desirable qualities in cutting tools.

When high-speed steel began to meet with competition from sintered hard alloys, many thought its role as a productive cutting tool was finished. But today the situation is different. Different materials are complementary to each other. Diamonds are used on cutting tools for precision work, but so far it has not been possible to produce synthetic diamonds large enough for use in industrial production. Here it can be expected that the development will offer new materials which it will pay to use for tools. Apart from the conventional steels there is a development towards more specialized steel alloys. Titanium, nickel and molybdenium will be used for many more alloys of machine tools. The ceramic tools containing aluminium-oxide are attracting much interest. In contrast to conventional cutting tools with a low carbide content, the ceramic tools have qualities that are important when shaping cast iron. Apart from machining, powder metallurgy also will be rapidly developed in the years to come.

We can discern three main lines of development:

1. Larger details will be manufactured.
2. It will be possible to work with a larger content of alloys.
3. New pressing and shaping methods will be developed(1).

The tendency towards larger work pieces has been clear for some time, especially in the American automobile industry, where today many workpieces are manufactured by the use of metallurgy.

New developments in the alloy field are also on the way in America as well as in Europe. Developments in the area of stainless material are especially noticeable. An interesting development which is likely to be adopted increasingly is the powder metallurgical shaping of heat-proof material for the construction of details in jet engines and gas turbines.

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(1) Hofsten, Fichmeister, Powder Metallurgy in Sweden, a lecture at the Powder Metallurgy Joint Group Tenth Meeting, 1967.

In the future we shall see new methods of pressing in order to achieve greater solidity. One can expect combinations of pressing, sintering, forging and extrusion.

Mechanization

The main consideration in introducing mechanization and automation is, of course, that it should be profitable. No enterprise can invest without some kind of calculation. The new machines must be profitable. The relationship between work and capital is of great importance for mechanization. How does the cost of labour develop in comparison with capital? At present the capital costs have increased slightly more than labour costs and in addition the capital costs have strongly influenced the rate of mechanization. The cost situation depends very much on the full employment policy. I suppose that, in the future, we shall have to calculate on the basis of a continued full employment policy with the same cost developments but perhaps at a slightly slower rate. You cannot talk about mechanization without taking into consideration the aspects of quality. A more automated production will naturally give a more regular quality of product. Difficulties in recruiting people for some jobs may also push mechanization forward, particularly in dirty and heavy jobs.

Future mechanization will be regulated, as before, by recruiting problems, demands for better quality and shortage of finance. Shortage of technical staff and other people suitable for working with automated machines may be a negative factor. This can be especially apparent on the maintenance side in the factory. At first the automatic machines are very expensive, more expensive than the manual ones. More mechanization will automatically mean a greater demand for more capital. In the late 1960's we have had a very small credit market.

The big capital cost of automatic machines is leading to longer production series and more effective use of capacity. Perhaps we must change our attitude to shift work in order to increase the interest in mechanization. Shift work is more profitable for the employers the higher their capital investment.

A serious objection to increased mechanization could be that the individual's satisfaction in his job might be lessened. Technical developments could turn all workers more or less into robots and give them a feeling of alienation from work(1). It is very important to solve this problem.

In the industry today there is a tendency towards a shorter life-span for products and this calls for shorter production series and increased flexibility of the machines. A numerically controlled machine is the most flexible. The opposite is true of transfer machines.

All machines installed today must be used for at least ten years. According to a study made by the Swedish Association of Metal Working Industries (Sveriges Mekanförbund) most managers of enterprises manufacturing numerically controlled machines think that numberical control will become even more important(2). They also think that even conventional types of machines will have numerical control. More functions will be controlled by N/C machines. Control by tapes will replace control by cards. Electronic pulse control will be more common. Fluidic systems will be more suitable for use in controlling and the electronic systems will have more integrated circuits.

None of the manufacturers mentions that there will be a fundamental change of the control principles during the next five or ten years. The manufacturers believe that 50 per cent of all new machines during the next ten years will be numerically controlled.

At the moment 85 per cent of the cost of machines is privately financed and 15 per cent is financed on the credit market. The high percentage of private financing does not necessarily indicate a high volume of investment, but may rather be a sign of a lack of credit facilities.

Changes in the Industrial Structure

It is obvious that the production units of Swedish industry are small when compared with those of the big industrial countries. It is often thought that this makes the country less competitive in the international market. Certain branches, such as the automobile industry, demand a certain minimum capacity. There are many examples of big industries which have much lower costs per unit than small ones. But if advantages and disadvantages are compared, big companies always have problems caused by too much formality and bureaucracy.

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(1) Inghe Den Ofärdiga Välfärden Tidens förlag, page 133.

(2) Mekanresultatet, No. 67516, Swedish Association of Metal Working Industries, page 11.

The biggest Swedish companies seem rather small in comparison with some of the big international ones(1). But one ought not to pay very much attention to this. When comparing different structures in most countries one finds that there are bigger differences between branches in one country than between one country and another. Many advantages can be obtained through co-operation between the small companies; and it is not certain that big companies have better financial resources than small ones.

The motives for rationalization and mergers vary, but some are more common than others. One aim is to have longer production series(2), and these will obviously affect the possibilities of mechanization.

The Machine Tool Industry

The engineering industry is the main industry in Sweden and produces a very big part of the total industrial production. Every year the engineering industry invests large sums in new machines. In 1965, 380 million Sw. crowns were invested in machine tools, 250 million of which were imported. The Swedish producers' group, the Swedish Machine Tool Manufacturers' Association, produced machines to a total value of 270 million Sw. crowns, 140 million of which were exported(3).

There are 95 member companies in this association covering 700 employees(3). During the last ten years production has increased by 97 per cent. Imports and investments have increased still more. The former by 190 per cent and the latter by 130 per cent.

Apart from the machines, which are already very important, other equipment will be substantially improved to deal with workpieces between the different manufacturing operations. Changing of material is today a very clumsy operation in automatic machines. Heavy workpieces are managed by special lifting equipment. The operator puts a rope around the finished work piece, removes it from the machine, lifts it up, moves it aside and lowers it into a box, removes the rope, moves the lift to the place for the raw material and the procedure is repeated backwards until the new piece of material is ready for machining.

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(1) Joe S. Bain, *International Differences in Industrial Structure - Eight Nations in the 1950's*, New Haven, 1966.

(2) *Industriförbundets tidskrift*, 2nd Edition 1967, page 20.

(3) *Mekanresultat*, No. 67516, Sveriges Mekanförbund, page 12.

Of course, it is a very time-consuming operation and very much can be done. New machines for handling will be produced, influenced by experience in areas where workers have difficulties in handling heavy material, such as for example, the forging industry. Manual manipulators for heavier workpieces have given new ideas for programmed automatic manipulators. Like the first car constructions, they are very primitive, with hand and arm movements like those of human beings. Manipulators are used quite frequently in the United States and Japan today. The same development will occur in Europe.

Assembling is a very important operation in the engineering industries, which has not been subject to mechanization and automation to the same extent as other operations. Automatic assembly machines are not unusual for long-scale production, but for small series they are almost unknown. To get more practical machines for common use, much work must be done on construction and design. We will, probably, have the same thorough transformation as in the case of the technique of numerically controlled cutting.

The most difficult operation for the manipulator is to trace the workpieces which are to be put together. If more manipulators are working in a line you cannot let the workpieces fall into a box, you have to place them on a stand or a runnel. It will perhaps be possible to have manipulators with two hands in the future, the second giving information to the first one on how to act. The manipulator will work like a blind man. Naturally it is possible to have light sensitized equipment in the machines, but this can never be developed to such an extent that the machine works as if it were controlled by a human eye.

In the future, electroerosive and chemical shaping will be more important(1). The laser technique can be used in hollowing, joining and measuring operations. The machines will be completed for handling automatic inspection control and there will be the same tendencies in the Swedish machine tool industry as in the American industry.

In 1966, 75 out of a total of 600 machine tool companies in the United States produced 87 per cent of the total production value(2). Mergers, vertical and horizontal expansions will be

(1) Verkstäderna, January 1968, page 159.
(2) Verkstäderna, 1967, page 159.

the common picture in the Swedish engineering industry as has been the case in the United States.

The Automobile Industry

The Swedish automobile industry is a modest one by international standards. Volvo, which is the largest company, made 160,000 vehicles in 1967, compared to Fiat with an annual production of some 1.5 million automobiles, Volkswagen with 1.2 million and Mercedes with 250,000. General Motors, which is the world's largest automobile company has a turnover comparable with Sweden's gross national product. The size of the automobile industry is always related to the size of the home market. If Volvo were to increase its production substantially, it would have to concentrate more heavily on export. At the present time over 60 per cent of the total production is for export. During 1968 the company hopes to reach 185,000 units. The total maximum capacity of Volvo is estimated at 260,000 units.

An eventual merger of S.A.A.B. and Volvo has often been discussed but has always been rejected by the respective managements, the advantages of the division of the market between the two makes being considered greater than the disadvantages.

The production of trucks in Sweden is relatively important although the actual number of vehicles produced is much less than the number of cars. The output of a company producing cars must be in the neighbourhood of one million per year for it to be considered as an important company. A company producing diesel trucks, however, is considered as important with an output of 10,000 a year.

The three big producers are Great Britain, Western Germany and the United States. Sweden is among the six biggest, and its production is dominated by heavy diesel trucks. Volvo and Scania Vabis number among the absolute elite in the production of this type of truck.

The Common Market situation has brought serious new problems for Swedish truck producers, who by tradition have tended to dominate in the Benelux countries.

The customs barrier around the E.E.C. is 22 per cent for cars; for components it is 14 per cent. 60 per cent of all the components of a Volvo car are produced in Sweden. 40 per cent are bought from abroad(1). Part of these come from the E.E.C. countries and are duty-free in Belgium, e.g. all Bosch components. After 1st July, 1968, the competitiveness of the foreign automobile companies will be further improved inside the E.E.C. for passenger cars thanks to the tariff reductions of the Kennedy Round. However, another worry has cropped up and that is the German railway transport protectionism which is hampering free continential road transport.

The Swedish car industry is concentrating very much on finish and trim in order to render its units competitive. No less than 10 per cent of the labour force at Volvo is assigned controlling functions. Great importance is also attached to painting and surface finish. In an automobile factory, practically the entire production can be mechanized and most of the machinery is automated. The production and assembly of car bodies can be done in automatic press and welding machines and in automatic body-jigs.

As far as body assembly is concerned, Volvo has come far in automation. The new 144 model is to a great extent welded in semi-automatic jigs. But the putting in and taking out is still done with the help of manual labour. In comparison with the Volkswagen works at Wolfsburg there is still much to be done. There the sections are first welded in semi-automatic jigs and are later joined and welded in entirely automated body-jigs. The Volvo management thinks it would not be profitable to increase automation further for the time-being. The number of Volvo cars produced is much smaller than the number of Volkswagens, and further automation would be too costly.

In the 144 version of the Volvo, some of the joining is done by gluing instead of spot welding, a method which has been used for quite a long time in the aeroplane industry. The difficulty has been to find a glue which can be used in the production of large series. Time-consuming hardening procedures and detailed cleaning of the steel sheets cannot be accepted in modern automobile production. The development in this area will be interesting to follow in years to come.

The Swedish automobile industry is, of course, guided very much by the experience of the American automobile industry. Developments in the field of security are definitely inspired by what has recently happened in the United States. The emphasis on various safety aspects has contributed to an increase in the consumption of plastic materials. The consumption of urethane plastics has increased thanks to the use of these for instrument boards, sun visors, arm rests, door panels, etc.

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(1) Veckans Affärer, No. 9, 1968, page 20.

That automobile producers are using progressively more plastic materials is clear from this Table (Modern Plastics, October 1967):

PLASTIC CONSUMPTION, KILOGRAMMES PER CAR IN AMERICAN AUTOMOBILES

1950 - 1967 AND A FORECAST FOR 1986

Year		Kilogrammes per car
1950		2.25
1955		4.5
1960		9.0
1962		11.25
1963		13.5
1965		15.75
1966		18.0
1967		25.65
1968	(estimate)	37.0
1969	"	40.5
1970	"	43.5
1975	"	53.0
1980	"	65.0
1986	"	80.0

In 1967 the plastic components of an American car weighed an average of 25 kilogrammes. By 1980 the figure is expected to have increased to 65 kilogrammes. The 144 model Volvo contains some 30 kilogrammes compared with 15 kilogrammes in the Amazon model. Automobile firms foresee a change to plastics in the first place for trimming such as front grills and some interior trimmings. Erik Strömberg of Volvo(1) has tried to list a number of substitutions that can be expect in the near future:

Carburettors entirely in amide or aldehyde plastic
Waterpump, complete in amide or aldehyde plastic

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(1) *Plastvärlden*, No. 3, 1968, page 45.

Battery case made from propane plastic
Upper part of a gear box in glass fibre reinforced polyester
Certain body components, e.g. engine hood or trunk hood
Gasoline tank in amide or olefine plastic or some plastic combination
Front grill in A.B.S. plastics

On the other hand Strömberg considers the possibility of constructing the entire body in plastic to be rather remote, because of problems of solidity. Present plastic materials cannot fill the same functions as steel in the major components. In addition, plastics also pose a problem as far as surface covering is concerned. Components other than those quoted by Strömberg would take so long to perfect that it does not serve any purpose to speculate on them in this paper. In addition to the plastic materials we also have the area of elastomeres, or rubber, where rapid expansion can be expected. Rubber is an essential material for the automobile industry. Apart from the tyres, hundreds of small components with the most varied functions are made from rubber.

There has been much speculation about an electric car for city traffic. The advantages of such a car are obvious in view of the air pollution caused by combustion engines. High sulphurdioxide contents and carbonmonoxide contents have contributed to increased activity in this field.

The Swedish A.S.E.A. has done some research in this field(1). It now makes an electric forklife truck powered with electric batteries. The combustion engine is most suitable when a great effect is needed over long periods of time. Batteries are suitable for use in a normal traffic and have the following advantages: low cost, extended life-span, little sound and vibration, no exhaust fumes, good initial acceleration and good reliability. There is no loss of power when regulating the electric effect of the battery. This system is built on thyristor regulation. At low speed the step (resistance) free thyristor regulation gives good control over the movement of the vehicle. Handling of fragile or bulky goods is made easier. Maintenance is limited to simple but important care of the battery and lubrication. The first prototypes ready for production in longer series were in operation in mid-1963. Production and sale of fork trucks began in 1964 and in August 1966 some 420 thyristor-regulated fork trucks had been delivered. The experience of those using the trucks is favourable.

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(1) *A.S.E.A.:s tidning*, No. 8, 1966, page 103.

In order to make the electric automobile more useful and practical it is necessary to develop a power system other than the traditional one. A.S.E.A. is carrying out comprehensive research in its laboratory in order to arrive at an efficient and cheap fuel cell(1).

The fuel cell is produced on an industrial scale at A.S.E.A. The greatest difficulty is not to develop single laboratory cells with high capacity, although this is a vital task, but to put the cell into industrial production. The fuel cell project has for some time been the largest development project of the A.S.E.A. central laboratory. The work has been geared towards developing a hydrogen oxygen system for submarines. The first stage of this work is now nearly completed. The fuel batteries and cells that have been developed in this project are now ripe for tests in other areas, e.g. trucks, earth moving equipment and city traffic (buses).

However, we shall have to wait for some time before these products have been sufficiently adapted to specialized needs to gain an important place on the market. This is also true of the aid systems of the fuel batteries. But we shall certainly very soon see an "electric" car for city traffic, and the traditional combustion engine will shortly disappear as the only alternative for shorter distances. On the other hand the conventional engine can also be expected to be developed along with the traditional car, especially as a means of comfortable transport over longer distances. It is too early now to give any dates for the introduction of the "electric" city car. But a change of the consumption system of this kind would certainly entail great structural changes for the automobile industry.

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(1) A.S.E.A.:s tidning, No. 12, 1966, p. 171.

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CHANGING WORK DUTIES IN THE MACHINE TOOL AND AUTOMOBILE INDUSTRIES

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This report attempts to discuss the subject of Changing Work Duties and new levels of responsibility for employees in 1980 as **seen** by a practical manager in industry concerned with general personnel work and training at all levels. The paper is bound, therefore, to differ in approach from those of research workers, able to predict or determine trends from detailed studies in several companies, backed by extensive reading.

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1. Introduction

In considering Education and Training for the Metal Worker in 1980 it is natural to approach the problem by considering the creation of New Work Duties and New Levels of Responsibility for Employees. It is recognized today that the most effective training programmes are based on a detailed analysis of the jobs to be performed, and techniques to analyse both the skills and knowledge requirements have been developed successfully over the last twenty years. Although it must be recognized that many training schemes have been devised without recourse to such techniques, it is accepted in the more advanced training circles that the competent professional trainer - as opposed to enthusiastic amateurs - must be skilled in the use of task analysis, skills analysis and programmed instruction. If not an expert practitioner himself, he must certainly have sufficient knowledge of these techniques to be able to employ effectively specialists as required. Failure to make use of techniques of analysis inevitably leads to unnecessary extension of learning time, inclusion of material not required to reach job competence, whilst essential learning is excluded and, not infrequently, seemingly excellent programmes that somehow fail to carry over to production performance. Analytical techniques can only be successful when all features of the job are known and the main requirements, in terms of sensory, physical and mental demands established. Thus from an analytical training point of view it would seem appropriate to discuss Education and Training requirements of Metal Workers from the base of new work duties and new levels of responsibilities for employees.

Inevitably there will be problems of accuracy associated with any form of long-term forecasting. We are aware that the rate of change is increasing and new techniques and ideas are being propagated at a near alarming rate. Yet it is a sobering thought to appreciate that 1980 is just as far in the future as 1956 is in the past. If we cast our minds back to the structure of jobs in our factories in 1956 we find that the similarities far outweigh the differences. Even allowing for the impact of new technologies and the greater rate of change in the next twelve years, it is probable that many existing jobs and work methods will remain just as they have done, indeed for not just the last twelve but the last fifty years or more. It is worth remembering that a technique as old as work study with its relative ease of application, ease of learning, low capital cost and proven short-term financial gains to management is today far from universally applied. How long will it take for managements that still shun work study to accept, for example, Numerically Controlled Machine Tools with their high capital cost and - at least according to some critics - dubious financial savings?

Even so, trends are clearly discernible. The real question that must be answered is whether we let the trends of technology determine the jobs that will be done in the future, or whether we shall take a basically new approach and deliberately design jobs in the future, possibly modifying the technological side of the enterprise in so doing.

The Socio-Technical System

Although the present concept of industry as a Socio-Technical System seems academic to some people, it is undoubtedly true that any manufacturing organisation consists of two separate sub-systems, each following its own laws. One is the technical system with its machinery, cycle times, plant layout, etc., and the other is the social system concerned with human beings, their organisation and their behaviour. We are now beginning to understand that to optimize the system as a whole we must consider both the social and the technical sub-system and that what is good for one half of the system is not necessarily good for the other half.

Optimising one half to the exclusion of the other will not lead to success. Thus we have seen the scientific management movement making great contributions in work study and method improvement and mass production techniques optimising the technical sub-system, but bringing with it problems of labour relations, turnover and quality. We have also seen the rise and fall of the human relations movement that sprang from the Hawthorne Experiments and flourished until production - orientated or results - orientated movements seemed to promise more. Both made the same mistake; each concentrated on just one of the two sub-systems. Neither gave a complete solution.

It would therefore be undesirable to continue in the future as we have in the past. We must not let discernible technological trends determine the content of jobs in 1980, but we must deliberately design jobs so that they compromise between the demands of this technical sub-system and between the demands of motivation, personal responsibility and job satisfaction of the human side of the enterprise.

Job Design in a Socio-Technical System

It is regrettable that relatively little is known of the criteria for successful job design in a Socio-Technical System. In an article by Dr. F.E. Emery, of the Tavistock Institute of Human Relations(1), which describes some of the pioneering work that has been done in the British Coalmining industry and the Norwegian iron/steel industry, an interim list of criteria for the design of jobs is developed under the following headings:

(a) Optimum variety of tasks within the job.
(b) A meaningful pattern of tasks that gives to each job a semblance of a single overall task.
(c) Optimum length of work cycle.
(d) Some scope for setting standards of quantity and quality of production and a suitable feedback of knowledge of results.
(e) The inclusion in the job of some of the auxiliary and preparatory tasks.
(f) The tasks included in the job should include some degree of care, skill, knowledge or effort that is worthy of respect in the community.

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(1) In "Manpower and Applied Psychology", Vol. 1, No. 2, The Ergon Press, Cork, Ireland.

(g) The job should make some perceivable contribution to the utility of the product for the customer.

It is my contention that in the 1980's we shall be training workers for jobs that take account of these criteria or others developed from them and that it is not meaningful to use extrapolation of present technical trends alone to determine the training and education requirements of the metal worker in that period.

2. Mechanization of Present Duties and the Creation of New Work Duties.

Machine Operators

Present trends indicate clearly that we shall see extensive use of transfer machines, a marked increase in the use of numerically controlled machine tools and the widespread use of new processes. In particular, sintering, metal forming and electro-chemical machining (E.C.M.) can be expected to replace the current metal cutting processes which are wasteful, because of the relatively large amounts of good material removed and converted into scrapped swarf, and dirty, because of the large amount of dust (particularly with cast iron) generated during the machining cycle.

The main effect on the operator of these technical developments will be the elimination of present duties concerned with material handling, machine loading and operation of machine controls. Thus the numbers of operators required will be greatly reduced and the demands of the technical sub-system on the few remaining operators will merely be to monitor operations and to be available for loading and unloading machines when faults occur, to start up and shut down lines and to carry out miscellaneous, often menial, duties. Tool setters will be required but they will use pre-set tooling and operate to pre-determined tool change patterns.

Such work organisation would fall far short of the requirements of the human sub-system. No doubt there are numerous alternatives but one solution that appears satisfactory to the author is to take advantage of the operators on the line by using their trained perceptual processes as an integral part of the maintenance process. Typical duties might be, in addition to any of the duties now carried out by an operator:

To monitor control panels and operating heads from station x to y and to detect symptoms of abnormal running or imminent abnormality, taking the appropriate action.

In the event of a breakdown to diagnose the nature of the fault and to determine whether to send for an electrical or mechanical specialist.

To carry out pre-determined tool changes.

Thus the operator will combine the duties of setter and also be responsible for determining the specialist required in the event of a breakdown. An analysis sheet designed to train unskilled operatives to make this decision is attached as Appendix 1.

Following the development outlined in section 3.1. these duties would be expressed in terms of objectives for the operators.

Assembly Operators

Long runs of sub-assembly or assembly work will tend to be automated and operators will be confined to short batches of mixed variety. The main factor holding up the advance of automated assembly now is the high machining costs involved because of the tighter tolerancing demanded by automatic assembly equipment. New machining processes will produce the required accuracy at acceptable cost, making automatic assembly economically viable.

As a result assembly operators will need to be far more versatile and with a greater understanding of the equipment they are building. Furthermore, operators will be employed to build complete units or major, identifiable parts of large units, again requiring greater skill levels and greater versatility.

Inspection and Testing will be largely automated. Because of the difficulties in rapid re-programming of machines and the complexity of machines capable of responding to several situations without re-programming, men will still be used where a wide variety of components have to be inspected in small batches or where the component line varies on a day-to-day or hour-to-hour basis. It is likely, however, that the majority of the burden of such inspection will fall on the manufacturing operator, and that by 1980 the large inspection departments required today will be seen as one of the cost penalties incurred by neglect of the requirements of the social sub-system.

To summarize, there will be considerable changes in operators' jobs in the 1980's requiring, in effect, fewer operators of high skill. In particular, machine operators will have well defined diagnostic and setting duties, whilst assembly operators will be confined to small batches of complete units. All operators will be responsible for their own inspection.

Skilled Trades

1. The expense of machine tools and their complexity will require greater attention to the reduction or elimination of machine down time. The greatest problem in doing this will be to develop diagnostic skills. The operator will have an important role to play here, but we can expect to see greater emphasis on diagnostic skills. There will be more emphasis, therefore, on mental skills and less on manual skills in the training of maintenance staff.
2. Machine tools will have greater built-in fault finding capacities. This will enable much routine maintenance work and preventive maintenance to be carried out by manual workers, but the need will remain for a 'Diagnostic Technician'.
3. The need for reducing down time will lead to a reduction of repair work on the larger and more expensive machine tools. The practice is likely to become 'don't repair - fit a spare' with the possibility of replaced items being sent back to the manufacturers for repair or being dealt with in centralized workshops.
4. We can expect a complete amalgamation of the mechanical and electrical/electronic trades. both at the diagnostic level and at lower levels of maintenance worker.
5. We shall see a marked decline in the trade of fitting. This will be because of the improvements that will come in metal forming techniques, e.g. turning, milling, grinding are likely to be replaced by metal forming and sintering processes which will reduce

> the need for subsequent fitting. In addition, such trades as plumbing and pipe fitting will be greatly affected by the use of new materials which will require substantially less manual skills in their utilization. Although there will remain many small firms using traditional processes with which we are familiar today, the small firm will be on the decline because of the larger capital resources of the larger company. There will be a decline in the fabrication work carried out because of increased labour costs and lowering costs of numerically controlled machine tools. If a new component is required, it is more likely produced by setting the co-ordinants on a numerically controlled machine tool than by utilizing a craftsman to produce it. It may be that the initial design of such components will be done entirely by computer and the drawings produced will be specifically designed for numerically controlled machine tools.

It would therefore be likely that some of the work duties currently performed by machinists in the craft areas will be replaced by work duties currently associated with computer programmers or computer operators.

3. New Levels of Responsibility for Employees

We can expect to see major changes in the levels of responsibility for employees for the following reasons:

It will become increasingly important to motivate workers more effectively. Apart from improvements in our knowledge of Human Motivation derived from advances in the Social Sciences, there will certainly be a move towards workers determining their own standards of performance rather than having them arbitrarily imposed upon them as now. Indeed one can see this as an extension of the practice of 'Management by Objectives' to embrace all levels of employees in the organisation. Considerable increases in productivity should result from this approach which in effect will give employees wider responsibility for maximizing their use of the resources at their disposal.

Individual or group objectives will be expressed in terms of tasks performed to previously determined minimum standards of performance. These will not be statements of ideal performance, but will relate to what can be achieved in a particular situation under existing conditions at the time the standards are established. They will therefore be subject to continuous review on the initiative of the individual or the group, consistent with the broad approval of the immediate supervisor. They will embrace the whole range of the operator's activity, not merely the output and quality.

Standards will be of two types:

Measured: Expressed in numerical terms, such as units produced, plant utilization, percentage rejects.

Judged: Those standards that are not readily measurable but which must have less objective criteria applied to them.

Measured standards will be relatively easy to establish but operators will require continuous feed back information to enable them to control their performance to meet the standards they have undertaken to achieve and to review these standards.

Judged standards will be set by asking "What conditions must be compiled with if the task has been done well?" For example, in the Job Description (Appendix 2) for an operator of a Churchill Internal Grinding Machine, the operator is required to follow a prescribed shut down routine. The associated standard is: "No start-up difficulties can be traced back to faulty shut down routine. Machine and machine area meet supervisor's Good Housekeeping requirements".

The requirements these standards have to fulfil are:

They must have immediate relevance to the tasks which the operator has to perform.

They must encourage the growth of personal and group responsibility by ensuring that operators fully understand management's need. They must be progressive and they must reject artificial restrictions of performance.

They must be simple and straightforward.

They must be capable of adaptation to meet the capacity of individuals.

They must co-relate with acceptable levels of payment.

The example in Appendix 2 sets out in realistic terms the main tasks of an operator, a statement of the conditions that will exist when the job is being done well, together with the information available to him to exercise control over his job.

The control information column indicates the sources of this information and shows who is responsible for making judgments of the operator's performance.

The comments column indicates the operator's degree of authority and indicates his relationship with other people in the shop. It could also be used to indicate the operator's ideas for improvements of performance.

Work Study will no longer be an acceptable technique for determining output because:

> Many more jobs will be limited by machine cycle time, not by the effort of the man controlling the machine.
>
> The acceptance of Learning Curve Theory will determine the minimum standard of output on a progressive basis for repetitive jobs.

An article "Learning Curves", from "Management Today(1)", gives an outline of Learning Curve Theory. Essentially this shows that with constant effort on repetitive tasks there is a constant and predictable improvement in output for as far ahead as it is significant to project. Thus, in effect, learning never ceases and with constant effort an operator's performance or output will naturally and automatically improve.

Under these conditions the normal work study techniques of direct measurement and rating or the use of pre-determined motion systems are static controls applied to a dynamic situation and are less valid than calculations based on predicted reduction in cycle time.

> As explained previously in this paper, the use of Standards of Performance for operators will lead to a change in the need for work study. Methods improvement will be a continuing need, but possibly as an advisory service to operators who will have primary responsibility for optimizing their working methods, but time studies will only be needed to establish initial minimum output levels.

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(1) "Learning Curves" by P.J.D. Cooke, Management Today, November 1967.

Status of Employees

One can expect normal social pressures to give rise to demands for "Staff Conditions of Employment" for manual workers. It will become important, however, for management to take the initiative in moving towards these conditions. Attainment of these conditions will necessarily mean that employees will have greater responsibility for avoidance of unnecessary absence from work when the economic pressures that are a feature of hourly paid conditions of service no longer exist.

The need for Management initiative in changing conditions of employment arises from:

> The requirement to attract more school leavers of higher academic attainment to jobs on the shop floor, particularly maintenance jobs. The change in work duties will mean that the manual content of jobs will be considerably lower, with more time spent on computer programming, computer operating and in purely diagnostic activities. Having employees of staff status will facilitate absorption of staff work duties into hitherto manual jobs (e.g. programming, computer operating).

4. Summary of changes in Work Duties and changes in Responsibilities

Operators

Reduction in machine loading duties

Reduction in operation of machine controls

Reduction in manual assembly duties

Responsibility for setting of tools

Responsibility for elementary fault diagnosis

Responsibility for own inspection and quality

Responsibility for setting and meeting own standards of performance.

Inspectors

Less need for line and patrol inspectors.

Material Handlers and Storeman

More emphasis on ensuring delivery of components and materials direct to point of need. The requirements will certainly be computer controlled and the computer may well automatically control actual deliveries to the point of need.

Skilled Trades

Reduction in fitting.

Elimination of trades such as pipe fitting and plumbing.

Marked changes in work duties arising from the replacement of turning, milling, grinding, with new metal forming processes and the increasing use of numerically controlled machine tools.

Increased emphasis on diagnostic skills.

Improved flexibility with the need for the development of "Control Engineering Skills" covering mechanical, pneumatic, hydraulic, electrical and electronic skills.

The addition of programming and computer operating skills.

Less repair of defective items and increased emphasis on identification and replacement of defective items.

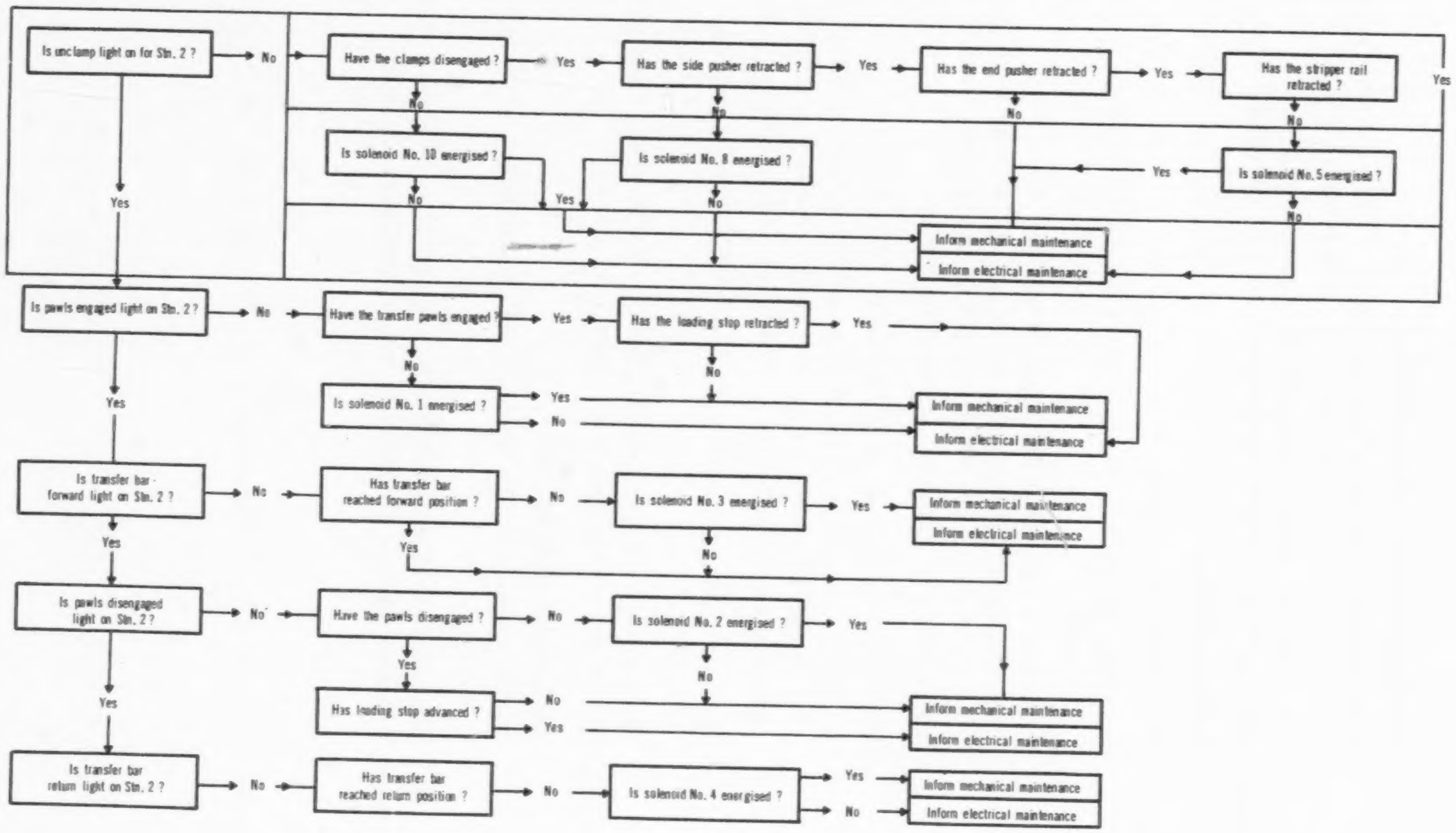
Work Study Engineers

Marked reduction in work duties associated with time study.

Change in method study with emphasis on advising operatives on how to improve their own work methods.

Appendix I

EQUIPMENT FAULT ANALYSIS 6/354 BLOCK - C.V.A. TRANSFER STATION 2


Is unclamp light on for Stn. 2 ?
No
Have the clamps disengaged ?
Yes
Has the side pusher retracted ?
Yes
Has the end pusher retracted ?
Yes
Has the stripper rail retracted ?
Yes
No
Is solenoid No. 10 energised ?
No
Yes
Is solenoid No. 8 energised ?
No
No
Yes
Is solenoid No. 5 energised ?
No
Yes
Inform mechanical maintenance
Inform electrical maintenance
Is pawls engaged light on Stn. 2 ?
No
Have the transfer pawls engaged ?
Yes
Has the loading stop retracted ?
Yes
No
Is solenoid No. 1 energised ?
Yes
No
No
Yes
Inform mechanical maintenance
Inform electrical maintenance
Is transfer bar forward light on Stn. 2 ?
No
Has transfer bar reached forward position ?
No
Is solenoid No. 3 energised ?
Yes
Inform mechanical maintenance
Inform electrical maintenance
Yes
No
Yes
Is pawls disengaged light on Stn. 2 ?
No
Have the pawls disengaged ?
No
Is solenoid No. 2 energised ?
Yes
Yes
No
Has loading stop advanced ?
No
Yes
Inform mechanical maintenance
Inform electrical maintenance
Yes
Is transfer bar return light on Stn. 2 ?
No
Has transfer bar reached return position ?
No
Is solenoid No. 4 energised ?
Yes
No
Inform mechanical maintenance
Inform electrical maintenance

APPENDIX 2

PERKINS ENGINES LIMITED JOB DESCRIPTION REF. NO. X	JOB TITLE:	INTERNAL GRINDER, CHURCHILL H.B.M. MACHINE
	GRADE:	004
	FACTORY:	EASTFIELD
	SECTION:	4.99 CON-RODS

I. GENERAL DESCRIPTION

(State main purpose of job in the Organisation)

To produce 296 good con-rods in 8 hours and maintain the flow of con-rods through his area.

II. POSITION IN ORGANISATION

A. DIRECTLY RESPONSIBLE TO: GROUP SENIOR

B. SUBORDINATES DIRECTLY SUPERVISED: NONE

C. PERSONS WITH WHOM HE HAS SPECIALIST WORKING RELATIONSHIPS: Group Senior, Line Inspector, Materials Handler, Maintenance personnel, colleagues with whom he is working in his section, particularly the Broaching Machine Operator and the Fine Boring Machine Operators.

III. SCOPE OF JOB

(Indicate total responsibilities in terms of men, materials, machines and plant facilities)

A. Churchill H.B.M. Internal Grinding Machine: Value £4,500 approximately

B. Miscellaneous equipment (diamonds, stones, gauges and components, etc.)

Diamonds	Approximately £30 each
Master Setting Ring	Approximately £5 each
Grinding Stones	Approximately 5/- each
Con-rod and Cap	Approximately 9/9 each (at the point where the Con-rods bores have been ground on this machine)

OVERALL TASK

(State principal tasks in which results are required if the main purpose of the job is to be achieved, e.g. Material and equipment utilisation, performance, quality, co-operation, communication, co-ordination, planning and progress.)

1. TASK ITEM No.	2. DESCRIPTION OF THE TASK (what the man is required to carry through to desired results (standard of performance)	3. STANDARD OF PERFORMANCE (description of conditions which exist when task-items are well done (i.e. desired results)	4. CONTROL INFORMATION (Used to show how well performance is achieving the desired results)	5. Comments on amount of authority and responsibility to carry out tasks, to improve facilities, standards and controls, etc. - If job holder does not have authority; from whom must he seek required action?
1.a.	MACHINE OPERATIONS START-UP ROUTINE: To ensure controls, power, pressures, hydraulics, coolant, equipment, gauges, cutting tools and machine behaviour are all in correct working order for production to commence. Details of Start-up Routine: i. Check floor area is clean and in safe working condition. ii. Check all oil levels are correct in machine. iii. Check air pressure is correct at 60 lbs. iv. Check coolant level and condition in tank is correct. v. Check correct gauges, particularly correct master setting ring, are in use. vi. Check clamps clean and in correct working order. vii. Check rods and fixtures clean before loading. viii. Check hydraulics working correctly after machine has stood idle. ix. Check safety guards in working order. x. Check position and correct functioning of machine controls. xi. Check emergency stop button. xii. Check diamond and grinding stone secure and in good condition. xiii. Check cross-slide working correctly. xiv. Check grinding stone being correctly dressed. xv. Check grinding stone sparking correctly, etc.	Start-up routine completed within first ten minutes of commencement of work and Group Senior advised all O.K. or of any failures.	Flow production of con-rods to required quality has commenced. Group Senior to check. Group Senior and Supervision check personally that no subsequent, early component faults and machine or equipment failures, are due to faulty start-up routine. Written records: Maintenance book, Inspection reports, weekly reject sheets, section record book, diamond change record chart. Verbal information from: Operator, Group Senior, Junior Foreman, Assistant Foreman, materials handler, maintenance and tool fitting personnel, safety representative for section and personal observation by Foreman.	1. The operator has full authority and responsibility to operate his machine and process con-rods at 296 per shift, 37 each hour and to acceptable quality standards. 2. The operator has full authority and responsibility to take action to control his operation (outlined in 1 above) by: a. personal activity to rectify faults within limits agreed with Group Senior and Supervision. b. informing Group Senior and/or Supervision of action other than his own which is required to rectify faults. c. informing Group Senior and/or Supervision of faults alone, if operator does not know which is the correct service needed to bring about the remedy. d. discussing with colleagues, Group Senior and Supervision, matters concerning the operation under his own authority, or that of others, which could lead to easier operation of the process or between processes. e. discussing, as above in (d), but concerning the supply of services and Company, factory, divisional and shop general information which can lead to better understanding.
1.b.	PROCESSING: To produce 296 con-rods, of acceptable quality in 8 hours, i.e. to maintain a flow of 37 con-rods per hour through the shift. Details of Processing Routine: i. To maintain the correct working order of the controls, power, pressures, hydraulics, coolant, equipment, gauges, cutting tools and overall machine behaviour. ii. To take the necessary action to rectify or get rectified any failure in (i) above.	296 con-rods of acceptable quality are produced in 8 hours at the flow rate of 37 each hour. Scrap %, due to his own processing faults does not exceed 0.4% (or 6 rods per 5 shifts). Stone changing time does not exceed 6 mins. (3 mins for stone, 3 mins for resumption of good production). Stone usage does not exceed 3 per day on average.	Production output records (daily and weekly) man-hours utilisation records, inspection reject sheets. Verbal information from Operator, Group Senior, Supervision, maintenance and tool fitting personnel, material handler and personnel observation by foreman.	

ITEM No.	DESCRIPTION OF TASK	STANDARD OF PERFORMANCE	CONTROL INFORMATION	COMMENTS ON AUTHORITY AND RESPONSIBILITY, ETC.
1.b.	PROCESSING (continued) iii. To maintain the requirements of 'good housekeeping' on his machine and machine area. iv. To take the necessary action to rectify or get rectified component condition, arising from previous operations, which will affect the quality or rate of flow of the components. v. To ensure the cleanliness, correct location for grinding, grinding finish and required quality characteristics of the components. vi. To utilise the available time efficiently to maintain the required production and flow of the components.	Coolant usage does not exceed 1/2 gallon on average per day. Diamond usage does not exceed 1 per month on average. Breakdown time does not exceed 2 1/2 hours per month on average. Group Senior's attention time does not have to exceed 1/2 hour per day.	Verbal information from Group Senior.	SEE ABOVE
1.c.	CLOSE-DOWN ROUTINE: To take the required action to ensure that the start-up routine will be smooth and requires the minimum amount of work and time. Details of close-down routine: i. To close down the machine controls in the correct sequence and to turn off mains power to machine. ii. To clean, check and store equipment tidily and safely in correct place. iii. To leave machine in state of clean, correct working order. iv. To leave machine area in clean, safe working condition. v. To leave components in correctly stacked positions.	No start-up difficulties can be traced back and due to faulty close down routine. Machine and machine area meet Supervision's good housekeeping requirements.	Personal checks by Group Senior and Supervision. Investigation of start-up faults by Group Senior, Junior Supervisor. Causes of faults reported by maintenance and tool fitting personnel. Personal inspection of section by Foreman at close down of shift.	
2.	QUALITY CONTROL: To ensure required quality characteristics, of components processed by him, are being fulfilled. Details of Quality Control: i. To check that the bearing groove has been machined in each rod before being ground and take required action if found absent. ii. To check for rusty or stained rods and take required action. iii. To check any misplacement between rod and cap after bolting up and take required action if found (Mulhead operation). iv. To check side faces of rod are free from burrs and take required action if found. v. To check correct gauges and master ring is in use and functioning correctly. vi. To check loading and clamping is correct prior to grinding (cleanliness, small-end bung, 60 lbs, clamp pressure, etc.). vii. To check operation of machine, diamond and stone are fulfilling and maintaining required functions correctly and to take required action if they are not.	Scrap % due to grinding process does not exceed 0.4%. Con-rods, scrapped for other reasons have not been processed. Con-rod faults, arising from previous operations, are properly communicated for rectification.	Verbal information from operator, Group Senior and Inspection. Verbal information from other operators. Written records from Inspection; daily and weekly reject reports, reclaim work records. Verbal information on machine, equipment, stones and diamonds from either maintenance, tool fitting, operator, Junior Supervisor and/or Group Senior. Written records on machine and equipment from maintenance, tool fitting, section maintenance book, daily report sheet.	Full authority and responsibility to control the quality of con-rods at his part in the process, including the check on his gauges. Authority and responsibility to submit his quality results to Inspection for checking. Responsibility and authority to take necessary action to obtain adjustments in the process to preserve or attain quality standards. Responsibility and authority to refuse to process already scrap components or components that would become scrap if he processed them without prior reclaim work being carried out on them.

ITEM No.	DESCRIPTION OF TASK	STANDARD OF PERFORMANCE	CONTROL INFORMATION	COMMENTS ON AUTHORITY AND RESPONSIBILITY, ETC.
2	QUALITY CONTROL (continued) viii. To check that large end bore is cleaning up and take required action, if found not, to get broaching operation modified. ix. To carry out 100% check with all gauges on first dozen components produced at commencement of work after machine has stood idle for a period of change of stone or diamond. x. 100% mercer clock gauge check on ground large end bore of all components processed - for maintenance of required limits. xi. Constant visual check on grinding pattern of rod bores plus other required characteristics that are checked visually. xii. Keep check on coolant condition and presence of oil, etc. xiii. Submit rods to inspection for all round quality checks including: Micro-finish (particularly when starting to use a new stone), bore chatter, checking small and large end bore centres, bore ground square to side faces, etc.	Scrap due to dirty clamps, poor clamping, dirty coolant, etc., does not exceed 0.4% or 6 con-rods per 5 shifts production. Inspection is used frequently, on average 5 times per day to avoid production of faulty con-rods.		AS ABOVE
3	COMMUNICATIONS: To ensure speedy communication of correct information to persons responsible for: carrying out any action required to maintain the correct behaviour of the machine, cutting tools, power, pressures, hydraulics, diamonds, stones, coolant, etc., and the maintenance of production flow and attainment of component quality. Details of communications: These will involve: i. Advice to Group Senior when on his tour, of action carried out by the operator or difficulties he is experiencing which might need further follow-up and checking by the operator, Group Senior, Supervision and/or other services. ii. Immediate reporting to Group Senior on any action required to be undertaken (involving any of the activities outlined in Task Item 1 a, b or c above) by other persons than the operator. iii. Advice to other operators, particularly on subsequent operations, on component characteristics which, although passable within his quality limits, can have a significant effect on subsequent operations. iv. Communicating to supervision on personal matters and working conditions which could or will affect or are affecting the operator's work in the Section, i.e. health, unsafe conditions, domestic problems, etc.	The Communications are clear, factual and correct, thus avoiding diagnostic investigation time, as far as possible, of supervision, etc. This would imply that the operator is right on his facts 9 times out of 10. Operators on subsequent operations enabled to adjust their own and avoid scrap production due to the grinding process, (e.g. bottom limit production). Scrap for this reason is NIL. Supervision are aware of the operator's personal matters and working conditions in adequate time to cater for these properly and smoothly in the discharge of their own tasks.	Verbal reports from Group Senior, Junior, Supervisor, Assistant Foreman, Inspection, Maintenance and tool fitting personnel. Comments from other operators. Personal experience by Foreman.	Full authority and responsibility to communicate, on all matters outlined in this task, to the persons concerned, via his Group Senior or Junior Supervisor.

ITEM No.	DESCRIPTION OF TASK	STANDARD OF PERFORMANCE	CONTROL INFORMATION	COMMENTS ON AUTHORITY AND RESPONSIBILITY, ETC.
4	SAFETY OF OPERATIONS: To carry out the tasks (outlined in 1 a, b, 2 and 3 above) in a manner which will ensure the safety of others and his personal safety. Details of the safety of operations: i. To ensure the proper and continuous use of guards. ii. To adopt a clean, tidy and methodical method of working in relation to his machine, machine areas, component stacking, use and placing of equipment which demonstrates his consciousness of the safety of others and himself. iii. To review as necessary, but not less than once per month, his working conditions and method of working, with the safety representative of the section and supervision to ensure the maintenance of safe practices and the improvement of them.	Accidents and 'near misses' due to operator's method of working state of machine area, stacking of components and behaviour of machine, are of the order of chance of one in 400 (in terms of shifts worked).	Written accident records. Verbal information from Safety Representative, Group Senior, Supervision and personal observation of Foreman. Written or verbal maintenance reports.	Full authority and responsibility to inform the responsible personnel of unsafe conditions and practices that he notices, either in relation to his own part of the process or elsewhere where he may come across them in the course of his proper employment. Authority to refuse to undertake action where he is convinced that this action is dangerous and unsafe, or where he feels he is not competent to do so.
5	CO-OPERATION WITH OTHERS. The co-operation to be sought by himself and others should include that which: i. Eases the task of maintaining the required amount and flow of good production off his own machine (e.g. good communications about operating difficulties, sensibly helping himself within the limits of his authority to do so, safety, etc.). ii. Eases the task of maintaining the required amount the flow of good production of subsequent operations (e.g. Buffer stocks, component quality from previous operations, etc.). iii. Eases the task of maintaining the good working order of his machine and equipment (e.g. constantly attempting to maintain or improve his work method for this purpose, cleanliness, etc.). iv. Eases the supervisory and section planning and output task (e.g. communicating in good time operating difficulties, absence from work, availability for overtime, helping out quickly on other operations if bottlenecks occur or if his machine breaks down, etc.). v. Eases the task of attaining maximum cost levels and improving on these by volunteering, discussing and pursuing ways and means to further reduce these costs (e.g. Not adding good coolant concentrate to coolant requiring to be changed very shortly, maximum use from grinding stones, wipers, overalls, gloves, not increasing feed and grinding rates to make up for disproportionate taking of personal time, starting up on time at shift commencement or after breaks, etc.).	Required amount and flow of production is maintained. Required amount and flow of production of subsequent operations is not reduced by causes arising from the grinding process. Breakdown time involving failure of his machine or equipment does not exceed 2 1/2 hours average per month. Supervisory tasks of planning and output are not upset or strained by operator's actions. Maximum unit/cost levels not exceeded by actions traceable to this operator. Cost reduction suggestions and actions by this operator are effective, in the section's aim to reduce costs below maximum levels.	Personal observation and experience of other operators, Group Seniors, Supervision. Display of man's own attitude. Speed of helping others. Man's awareness of section's problems, seen through his discussion of them with others and his willingness and helpfulness in reducing them. Quantity of cost reduction suggestions from men and quality of them. Usage records for coolant, diamonds, stones, maintenance and breakdown records.	Full authority and responsibility to seek, suggest and persuade others on the matters outlined in this task and which will lead to better results than those which are at present obtained. (Inclusion in the Suggestions Scheme of cost reduction suggestions concerning his own part of the process and his own section. If suggestion is accepted and cost reduction target reached in his own part of process, or by section as a whole, a benefit reward to the suggestor and participants).

PERSONAL CONTRIBUTION

(Besides the important personal contributions that the operator is already making, particularly under Item 3, 4 and 5 as described in the Overall Task, i.e. Communications, Safety of Operations and Co-operating with others; are there any further activities or improvements in these areas or others, which the operator can suggest can be contributed by himself or others to improve either his own overall task, the tasks of colleagues or the operation of the Section?)

ACTIVITY	HOW DOES IT HELP?	CONTRIBUTED BY HIMSELF OR WHO?

Signed by: ....
(Job Holder)

Signed by: ....
(Foreman)

This job description MUST be reviewed by the job holder and his manager at NOT MORE THAN 6 months interval or when a new job holder occurs. For the same job holder the next agreed date for a review, unless required earlier by either party, is:

CHANGING WORK DUTIES IN THE MACHINE TOOL AND AUTOMOBILE INDUSTRIES

by Fritz HAUSER
I.G. Metall,
(German Metal Workers' Union)

On the basis of economic and technological developments during the last ten years in the automobile industry, it is only possible to determine some likely trends in industrial employees' job duties up to 1980.

The assumption is that this branch of industry will expand still further and will thus be compelled to increase its efforts in the investment field as well as in the resulting man/machine system.

Another consideration is the extent to which standardization and unification of certain construction materials and groups will influence the trend towards further mechanization which in turn will result in changes in the tasks of production and maintenance personnel. In order to base our report on as solid a foundation as possible, we shall examine changes in the following production sectors:

1. Machine-governed production activities.
2. Observation of mechanized units within the production process.
3. Assembly line and single production tasks.
4. Transport activities.
5. Inspection activities.
6. Tool and appliance production activities.
7. Plant servicing and maintenance activities.
8. Activities connected with testing and developing improved production processes.

It is only by detailed study of these eight points that we shall find examples of new or altered job duties which will give us a picture of changing trends making way for new activities.

1. Machine-governed production activities

The economic utilization of highly mechanized installations such as transfer machines or multi-purpose machines requires a further sub-division of hitherto complex job duties in the car industry. Thus the job duties of a machine operator are being changed into observing and occasionally adjusting pre-set machines and tools. In addition, there will be an occasional exchange of pre-set equipment. The setting up of machines, tools and appliances becomes increasingly the task of special setters.

The process of setting and minor programme modification demands a wealth of new knowledge in automatic control, hydraulics, pneumatics and the combination of electronically monitored production machinery and transport installations. Machining or forming requires a knowledge of working new or improved materials. The processing of plastics and sheet metal laminates for car bodies or the manufacture and thermoplastic moulding of nylon gear wheels are examples of this.

Setting up and regulating electrostatic spray processes or painting of car body components by dipping, taking into account the maximum economic and technical potential of the installations, will create additional tasks for the machine setter.

The adoption of ceramic cutting devices and the forming and compressing of surfaces on shafts and gear wheels on programmed machine tools results inevitably in new job duties for which no comparable equivalents exist, which might often easily be co-ordinated between machine setters and operators.

2. Observation of mechanized units within the production process

The use of complex processing and assembly units requiring different numbers of operations demands, apart from the control functions, the necessary observation functions. Monitoring and warning devices are necessary for the entire installation, i.e. for sequences of welding or car body press operations as well as transfer machines. In such cases, in addition to specific knowledge of the plant, decisive action is needed for coping with minor operational incidents. Initiative and ability to co-operate will be required from both the team and their supervisors. We are dealing here with individual stages of the working process, demanding quick mental reaction, decision-making and constant alertness to deal and act whenever necessary (occasional help with repair tasks expected).

3. Assembly line and single production tasks

The trend towards job simplification in assembly activities will in the next few years be accentuated by the oriented application of O. and M. This will tend to lead in particular to improved jig and tool design and routing of components to arrive in the right spot at the right time.

Simultaneous job duties will be introduced predominantly at single work stations. Wherever possible, the assembly functions will be fully or partly mechanized. Transport and inspection functions will either become completely obsolete or be delegated to other departments.

Single job functions will be taught in special training rooms by highly qualified personnel and will require thorough knowledge of the practical and theoretical process as well as some teaching ability.

4. Transport activities

The movement of parts being a determining cost factor in car production, such movement will, wherever possible, be fully or partly mechanized. Some of the job duties will here consist in servicing transport units, conveyors and automatic warehousing installations, and wherever economic reasons preclude mechanization of transport, parts will be moved using ancillary transport equipment. Servicing such equipment (such as magnetic lifters, pneumatic vacuum lifters, etc.) requires persons capable of handling it. To a minor degree some transport functions are still delegated to operators.

Summary: Production Area

On the changing characteristics of job requirements and plant organisation during the next twelve years will depend the following typical activities in the automobile industry. They may prevail either singly or collectively.

(a) Supply and feeding of raw materials and parts to machinery.

(b) Single operations on single-purpose machines or assembly work.

(c) Observation activities (machine minding and work flow).

(d) Monitoring activities on machine tool lines or transfer units.

(e) Setting and adjusting activities on single machines or transfer units.

(f) Minor programming functions on single machines or machine lines.

(g) Inspection activities (quality, quantity, etc.)

When investigating the above activities according to qualification and with a view to the future, the following results are obtained for groups (a), (b) and (c).

The exercise of these activities requires less vocational training and specialization either on the manual or mental level because of the trend towards job simplification and method study.

Demands on the senses and, occasionally, on resisting monotony seem to gravitate away from existing patterns. Categories (d) to (f) will require a larger amount of know-how, particularly (e) and (f), as they have not had particularly detailed training up to now. Skill requirements for group (d) will vary according to the need for changes in the plant and in job duties and the form monitoring is liable to take. Group (g) will by and large call for lower requirements due to the introduction of foolproof control equipment, while a small segment of control functions will require considerably more extensive knowledge, mental agility, ability to react and responsibility.

5. Inspection activities

Inspection of materials and quality and size control are largely absorbed by co-operative efforts between inspectors and setters either in a reporting or an adjusting capacity. Manual inspection tasks are carried out by incorporating or servicing electronic, photo-electric and pneumatic control services. This is done either automatically or based on the readings of signals requiring a "Yes/No decision".

Perfecting existing mathematic/statistical procedures for production control will demand, apart from the manipulation of inspection equipment, increased technical know-how.

6. Tool and jib production activities

With the introduction of complicated machine tools, assembly and transport machines, job duties will tend to grow depending on the extra work required to run these machines. Apart from conventional job duties it will be necessary to handle the most modern optical precision instruments, e.g. high-precision drills, special machines for spark erosion, and ultrasonic generators, particularly within the tool-and-die making areas of the automobile industry. Knowledge of the relationship between machine tools and the necessary tooling on the one hand, and electronics, pneumatics, hydraulics and their incorporation into complex production systems, can be gained in some measure only with additional experience.

Obviously, there will be trial-run tasks testing the behaviour of new materials such as thermoplastic and thermosetting plastics for subsequent incorporation in components. Manipulation and moulding of epoxy resins when styling car bodies and designing press tooling will require specialized job duties. Thus we may summarize as follows:

New production techniques such as programmed machines, introduction of new materials and planned methods study for manual tasks are bound to demand a higher degree of training and skill than before from the personnel responsible for the production of jigs and tools for these innovations.

7. Plant servicing and maintenance activities

It is not possible to indicate a clear idea of the trend in job duties in plant servicing and maintenance on the basis of the present findings.

The trend will, in the main, be towards one of the two following alternatives. Under plant streamlining policies the present highly qualified employees may merely exchange specific units on machine tools and, because the unit removed is highly complex, will then send it back to the tool manufacturer for repair. This obviously requires less skill and experience in the sector. The other alternative is to run a very highly developed repair department with highly-skilled personnel capable of adjusting the many machine tool systems, whether mechanical, electronic, pneumatic, hydraulic or programmed. This would involve a repair department in relatively high costs and is therefore less likely to be realised. Advances in preventive maintenance will have decisive implications on job duties for maintenance staff, and such progress would eliminate fault finding duties for tool machines and their repair.

8. Activities connected with testing and developing improved production processes

Because of the prevailing keen competition in the automobile industry, producers will tend to enlarge their development and test centres in the next few years. These centres will experiment with production techniques, styling, automobile construction and road worthiness using the latest methods. No basis exists for estimating the job duties of personnel employed there. It is safe to say however that skill, experience, adaptability and initiative on specific tasks will demand a measure of qualification not yet attained.

Trend of job duties in the tool manufacturing industry up to 1980.

In evaluating the trends of job duties for personnel in the tool manufacturing industry up to 1980, we can again only trace certain tendencies.

We can already discern that firms producing a certain type of machine tool are veering towards more specialization.

When building general-purpose machinery, producers will be obliged not only to develop their product designs mechanically and electronically, but also to build easily convertible, programmable machinery.

A second group of more specialized tool producers will concentrate on the design and construction of transfer machinery, and purpose-built machines for process line production.

Changes in job duties

While personnel in the mechanical production sectors such as milling, turning, heat treatment, etc., will remain at their present-day high level of qualification and will, at best, adapt to new methods and materials, the job duties of personnel dealing with installation and repair will undergo a change.

In particular, setting and adjusting functions on advanced machine tools will require additional training in electronics, hydraulics and programmed control systems as well as the ability to understand the position in the sequence of production operations. Servicing of oscillographs for checking the function of machine tools as well as the handling of precision electrical measuring instruments will gain emphasis in addition to the traditional tasks of installing and dismantling complicated machinery. Job duties such as bonding of metals, welding of synthetics, electrolytic drilling of metals, ultrasonic processes for welding, milling and drilling will continue to develop in the next ten years especially in the construction of machine tools. The basic concepts of programming machine tool production will have to be defined in co-operation with electronic data processing specialists.

Similar increases in job duties are likely to affect repair personnel with regard to exchangeable units and single-purpose machines. The increasing number of variables involved in fault finding with such complex machinery is bound to require more intensive skill and experience in a field which up to now did not specifically need these qualifications within the machine tool producing industry.

Summary

While the job duties of automobile industry personnel are developing at a very uneven place and new job descriptions by job level or trade are as yet not realistic, the trend in machine tool construction gives a much clearer picture. Here, job descriptions can be supplemented by the analysis of new job duties. By modifying and eliminating outmoded job concepts, a forecast of requirements in that industry up to 1980 is quite feasible.

If we look at the trend in both industries not only from the technological and administrative angle but also from the individual's viewpoint of security of tenure for the person who, during his working life is repeatedly obliged to adapt himself to a number of different job duties, we then see the need for providing broader vocational training in line with the new technological requirements. It does not matter whether this training is fully utilized afterwards at the individual's work station or not.

PROSPECTIVE JOB PROFILES IN THE EUROPEAN MACHINE TOOL AND AUTOMOBILE INDUSTRIES IN 1980

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Previous papers have emphasized the technological and managerial changes which can be expected to occur during the next twelve years. The internal (for the individual firm) pressures of technological innovation in both manufacturing technology and materials will force managerial changes which are already discernible(1). Material changes will keep pace with, or even out-date, the advances in manufacturing technology, and the broadening of the range of manufacturing techniques for any given product will force changes for shop floor personnel more radical and more frequent than is usual today. The external pressure of changing markets will also force managerial and technological changes. The growth of indigenous machine tool and automobile industries throughout the world may cause the export of skills and ideas rather than products from Europe. Where products are needed the successful exploitation of markets will require a quick start to production or the supply of specialist equipment not obtainable elsewhere. The former requirement in particular will call for managerial integration and participation throughout the organisation. Such pressures for managerial change will modify work duties at all levels of the organisation and cause a redistribution of the necessary operating functions of manufacturing systems. At the lower levels these will impinge on the currently traditional activities of shop floor workers, modifying their job profiles accordingly. Indications of the resultant profiles will be given later in this paper.

Another major pressure which will affect the job profiles at all levels, but in particular at shop floor level, arises from the changes within society itself. Greater measures of social and political equality and ready means of communication, both physically and of information, are contributing factors in the changing of our society from one where necessity was, to a great extent, the coercive determinant of behaviour to one where consent and choice are commonplace across wide areas of people's lives. In terms of Maslow's(1) concept of a need-hierarchy, with the substantial satisfaction of some of the "lower" needs, such as the "physiological", "safety" or "belonging" needs and the steadily increasing experience of being able to satisfy egoistic and self-fulfilment needs in the wider range of roles which an affluent society presents, the expectations of the shop floor worker will not be met by job profiles or management activity based on simple models of man, crudely guessed from generalized behaviour patterns. Many of the commonly held beliefs deduced during earlier stages of the industrialization of society, will need replacing by concepts arising from the behaviour of people in society today.

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(1) Woodward, J., (1965) Industrial Organisation, Theory and Practice. Oxford University Press.

Where the activities available to a man over the greater part of his life were restricted by necessity, the acceptance of this necessity was a requirement of survival; kicking against the pricks lead to the destruction of the man and his dependants. But necessity is no longer the curb. Most Europeans can now choose whether they stay at home or drive into the country, have their holiday in the hills or at the sea, or buy new furniture or have another child. Consent to the decisions which affect their lives is part of their common experience and the evidence is growing that European men will not accept it otherwise. The car production line manned largely by immigrants from outside Europe, the widespread growth of joint decisions in factories over working conditions, all point to a changing viewpoint in working society which will not accept dictation. If the job dictates behaviour, then it is less attractive as a job and the choice available to the employer for manning that job is consequently limited. By 1980 the reality of this change will have forced the acceptance of the "job design" concept, a concept considered as hopelessly idealistic less than twenty years ago.

Many workers in the last two decades have studied the problems of job design, the complex interactions between attitudes to the job, job content and performance(2). The contribution made by these factors to motivation is still being explored.

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(1) Maslow, A.H., (1954) Motivation and Personality quoted in J.V. Clark, (1960) Motivation in Work Groups, a Tentative View. Human Organisation, 19, pp. 199-208.

(2) See, for instance, Davies, L.E., Canter, R.R., & Hoffman, J.F. (1955) Current Job Design Criteria, Jnl. Ind. Eng. 6, 2. (1962 Automation and Job Design. Inc. Rels. 2, 1.

Briefly summarized, it appears that work to the worker should provide opportunities for the acceptance of some responsibility for the work, for decisions about sequence and method, for the completion of a meaningful unit and for recognition of its contribution to the work of the plant as a whole, for identification with the purposes of the plant. This brief list does not imply that more traditional motivators are unimportant, it is not intended to be comprehensive in scope but to indicate some areas which will influence modifications in job profiles in the future.

So far, this paper has indicated the background against which job profiles may be viewed. The situations presented in earlier papers, together with the trends given above, are proposed as the determinants of the job profiles of the 1980's. What, then, are these profiles likely to be?

It is improbable that man will still be being used to fill the gaps in an automated system, used as a process link because technology cannot economically provide an alternative. No doubt he will be more remote from the production point, there will be an element of "minding" in his work, rather than "direct operating". But, at the same time, it is unlikely to be possible to eliminate man from the direct production area in the foreseeable future, since more frequent changes in product, material and technology will limit the possibilities for investment in a fully automated technology.

The continuing trend towards more integrated production, both for complete units, such as automobiles or for integrated machining and assembly activities such as numerical control can provide for machine tool manufacture, will lead to increased managerial authority on the shop floor. As mentioned earlier the trend already identified by Woodward(1) is not an accidental effect of technological advance but a necessary and deliberate step by management to increase its effectiveness by eliminating redundant functions and restructuring jobs.

A manufacturing facility requires the following operational needs to be satisfied at each work centre in the system for its successful operation.

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(1) op.cit.

Action

Loading or unloading of material
Manipulation of controls
Sequencing of products
Maintenance

Information

1. Material (a) quantity
   (b) quality
   (c) state
2. Equipment (a) performance capacity
   (b) utilization
   (c) maintenance state

The first two "actions" are common practice today in machine operation, although they may well get less common. The last two actions do not usually apply, but will get more common. Equally, with the possible exception of 2 (a) under "information", the most accurate source of the other information needed is at the manufacturing centre itself. Releasing the operator from being a link in the process sequence, a necessary step for efficient equipment utilization, presents opportunities to use his unique facilities for decision-making on qualitative data, his inferential capacity and his capacity for rapid change.

Thus equipment will be designed so that first level management functions now performed by progress chasers and production control clerks, as well as primary preventive maintenance and unit replacement, will become part of the shop floor workers' activity. Information as listed above, either at regular intervals or as called in by higher level management, will be passed both vertically and horizontally to aid decisions at all levels. The concepts of "shop floor" and staff will be redundant.

The removal of the operator from the role of a process link also reduces the technological tie with his manufacturing materials. The "materials" focus noticeable at present, as well as the "trades" focus, will be much reduced, for the machine will provide the necessary contributions here and whether the machine forms plastic or metal, whether it assembles, cuts or prints, will be of little importance to its operator, whose "trade" will be "machine manager", rather than "miller" or "fitter".

One big feature of job profiles as such will be their lack of rigidity. One man, in his time, will have to play many parts, and the contribution of education and training to this is discussed by later contributors. Not only will this training and education be needed to enable the worker to encompass change, but man's inferential and decision-making abilities will have to be deliberately developed, much as his manipulative abilities are developed in training schools today.

As an example of the direction in which job profiles will change the results of a study of the effects of technological change on skill may be quoted(1). In this study, job profiles in respect of motor, perceptual, conceptual and discretionary skills were prepared for 8 pairs of workpieces, each being performed both on numerically-controlled and conventional machines. The study covered four different firms. Five levels of each skill were defined and the operator's job split into setting up, operating and checking tasks. Note that little managerial contribution was considered in this study.

Each comparison pair was examined to find where differences in the skill level under any of the twelve hearings occurred. These differences which indicated the change occurring between each of the eight pairs of contrasted jobs, were averaged over all the eight jobs, giving the profiles of figure 1. It will be noticed that manipulative and discretionary skills are not called for to any significantly increased extent with N/C - machines - indeed there is a slight reduction, the demand for these skills appearing more in favour of the "conventional" machines. (Recall that no analysis of other work performed by operators was carried out, only that work related to the operation of the machine in each case). The major increase in skill comes in the perceptual and conceptual areas. Thus the ability to interpret and relate controls and their effects, information interpreted into action, monitoring of performance at a high level; the ability to infer action from indirect information, to relate abstract information to concrete situations and to work from a mental "model" of a situation are all representative of the changes to be found from this study.

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(1) Hazlehurst, R.J., (1967). Numerical Control and Changes in Job Skills. Unpublished M. Sc. Report. University of Birmingham, Department of Engineering Production.

If the same structure for skill breakdown is considered in relation to maintenance, the shaded section of figure 1 is suggested as a possible profile for this function. Assisted by adequate job aids, the skill levels will be low, although higher than those usually found in machine shops today.

The tasks forming the profile, when summarized, will probably be as in figure 2. The first profile represents the percentage of the five major tasks suggested as the constituents of the job. Machine monitoring will probably be required for most of the time, even during the performance of other tasks, although the actual attention received by the machine will be very much less, as shown by the full line. The "management" content will increase very much over today's minimal level, not only including the information and decision aspects mentioned earlier, but also including a significant amount of personal responsibility for negotiating his own performance within the production structure. As with other aspects of the job, consent is likely to be more evident in this area than at present and agreement more acceptable than dictation. For the automobile worker the profile will be different and this is also presented in figure 2. With a considerable part of the job still likely to involve actual handling of material, or controlling its assembly, the manipulation and control of assembling will be a larger component of the profile. Equally he is still likely to be a little more dependent than his machine tool colleague on operations co-ordinated with those of his fellows, and thus more limited in his opportunity to set individual operating norms. Checking, however, will play a larger part in his task than it does today, for his responsibility for quality will be increased over that of present day automobile workers.

Initially, better education will not only have spread the narrow technological base of the worker to enable him to encompass the necessary electronics or programming for elementary maintenance and modifications to his equipment and its operation, but the wider and deeper levels of basic education achieved will provide a population better able to be flexible. Job changes may be more frequent as a result, this would be determined by many other factors outside the scope of this paper. On the other hand, the increased availability of better educated people would enable higher management to create job profiles more in line with the operational needs of the enterprise, rather than biassing technology to compensate for observed or assumed lack of abilities in the available working population, as is done today.

Figure 1

AVERAGE (OVER 8 JOBS FOR EACH TYPE OF m/c) OF EXTRA SKILL NEEDED IN EACH SKILL CLASS

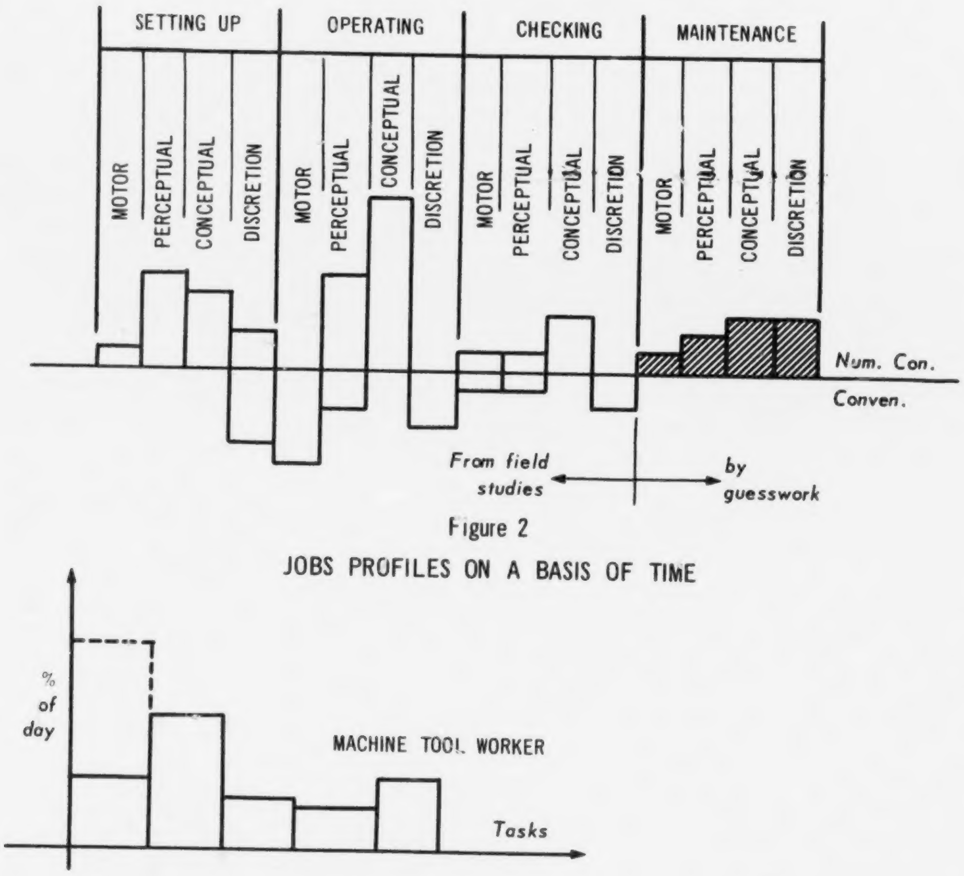
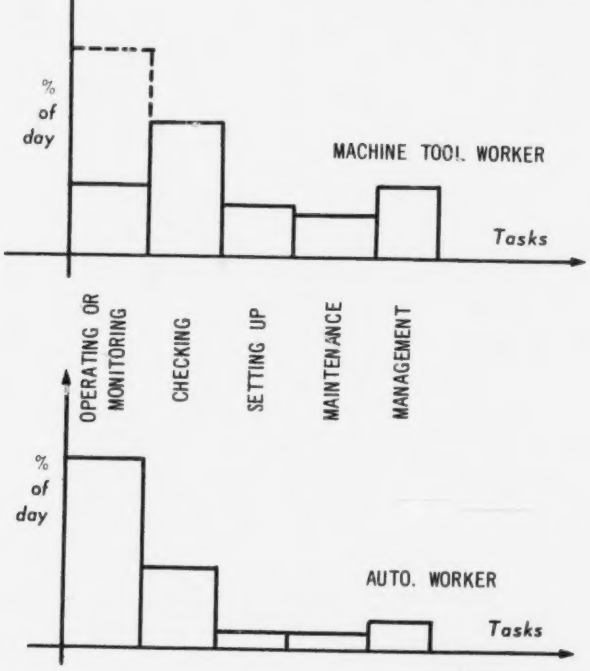


Figure 2

JOBS PROFILES ON A BASIS OF TIME



PROSPECTIVE JOB PROFILES IN THE MACHINE TOOL AND AUTOMOBILE INDUSTRIES

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The purpose of this seminar is: "to consider the most desirable systems of general and vocational education and training for youngsters now entering upon their schooling in terms of the demands likely to be made on them by society and the work in these two industries in 1980".

In this context the subject of this paper is:

- the relevancy of the concept of job profiles to the problem and
- whether job profiles can in fact be forecast.

The introduction of the concept of job profiles into the process of devising a training policy implies a value-judgement on which training systems are the most desirable. We will therefore first examine how the concept of job profiles relates to different possible approaches to the problem.

The answer to the question of which training policies will achieve the most desirable training systems, will depend on whether preference is given to the industrial demand approach or to the social demand approach.

The industrial demand approach starts from a notion of what is needed for the most efficient functioning of the industrial apparatus in terms of quantity (skills required) and quality (numbers of jobs) in each occupational category(1). This approach therefore aims to make forecasts of both the qualitative and quantitative aspects for use as guidelines for a vocational education policy.

The concept of job profiles is of paramount importance for both the qualitative and the quantitative aspect. Changes in job profiles consist of a reshuffling of job duties accompanied by a contraction or an expansion of the number of job duties within each job; therefore the job profiles determine the contents of the jobs as well as the number of workers needed to perform them. The job profile may be changed because of a change in labour supply and demand, because of changes in job duties determined by the advance of technology, or because of some combination of these two.

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(1) Occupational category defined as the group of jobs with more or less the same job profile.

The social demand approach seems the exact counterpart of the industrial demand approach in that, instead of specifying the needs of industry, it specifies the aspirations of the population, leaving it to industry to adapt its job structure so as to be able to employ a labour force with a given structure on an economically efficient basis. Here again the concept of job profiles is relevant since it is by changing the job profiles that the industry's job structure will be adapted to the given structure of the labour force. This time, however, knowledge of future job profiles is neither relevant nor necessary for vocational training. The social demand approach needs knowledge of the population's aspirations.

The industrial demand approach therefore would use estimates of the changes in skill and knowledge required by industry in order to devise a training policy that will help the labour market authorities to produce a similar change in the skill and knowledge available in the labour force. The social demand approach wants a training policy that responds to the population's aspirations. It will have to estimate the effects of such a policy on the skill and knowledge available in the labour force in order to supply the labour market authorities and industry with information on how job profiles should be defined - and in the longer run how investments should be directed(1) - so as to obtain requirements which correspond with the estimated capabilities of the labour force.

It can be concluded that knowledge of future job profiles is relevant and necessary for the industrial demand approach; but it is neither relevant nor necessary for the social demand approach.

We have so far passed over a rather obvious difference between existing and future job profiles. The obvious difference seems to be that the former can be observed and that the latter should be forecast. The outstanding difference is that the observation and the forecast cannot be made to deal with the same concept. The existing job profile gives a description of what some particular worker is actually doing at some point of time. It includes the contribution of this particular worker's qualities or lack of qualities. It is in fact the combination of man and job which makes up the job profile. We will call this observable job profile the subjective job profile. It should be clear that by using the term "subjective" we do not mean that it is the worker who decides upon the job profile, but that no complete observation of a particular job can be made if the occupant of the job is excluded from the observation. Without the man the only observable thing would be a series of job duties.

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(1) In the short term industry's job structure should be adapted by changing the job profiles. In the longer term the job duties themselves may be changed.

Future job duties can be characterized as: a series of job duties which are not yet assigned to somebody. The only way to bring some order into these series is to make use of some formal concept of job profiles, i.e. to transform them into a specific number of specified job vacancies. The obvious difference then between existing job profiles and future job profiles is that the former describe what a particular worker is actually doing whereas the latter describe nothing more than some assumption concerning the way in which some future job duties may be assigned to some - as yet unknown - worker. So, before starting to make forecasts we should first decide how to arrive at some principle according to which future job duties will probably be arranged in such a way as to make up a specific number of specified job vacancies.

The only intelligent principle from an employer's point of view seems to be the one that would achieve the lowest possible wage costs. In practice, however, very few employers act exclusively on such a basis. Trade unions, law and customs (including the employer's own customs) all contribute to their being a more complicated kind of human being than appears in the economic textbooks. But we may perhaps assume - as economists do - that entrepreneurs do at least try to act in this way. As a matter of fact the extent to which they do so will not be the same for all countries and we will not attempt to make an internationally relevant generalization concerning the complete principle that governs the definition of formal job profiles. It will, however, be convenient - and relevant for at least some jobs in most countries - to think of a formal job profile as a uniform set of job duties defined for the purposes of wage regulation and recruitment of workers.

Defined for purposes of wage regulation, the formal job profile should provide information on the kind and number of job duties which a worker should be able to perform, and be prepared to perform, in order to be entitled to the basic wage for the kind of job.

Defined for recruitment purposes, the formal job profile will have to provide information on the performance required and how these requirements relate to some basic wage.

The employer will have to provide this information in such a way that those workers whom he seeks to employ will apply.

There are several ways of defining formal job profiles, but the examples given suggest that one may reasonably well assume that any formal job profile will amount to a rather close approximation to an actual job profile. So for purposes of recruitment we may assume that the concept of a formal job profile stands for an occupational category defined as in the group of jobs with more or less the same job profile.

If an employer wants to employ more workers in an occupational category which is already known to him, he will define the job vacancies in terms of this occupational category if he expects that there are some workers on the labour market who are on average similar to the workers whom he already employs.

We speak of a stable relationship between the internal and the external labour markets if on both markets the same definitions of occupational categories exist; if on both markets these categories can be related to groups of workers possessing the same type and level of skill; if on both markets similar ideas concerning labour conditions are attached to these categories, and if neither the employer nor the employed, or potentially employed, workers expect a sudden change in this situation. Under these conditions, job vacancies will be defined in terms of the existing occupational categories. So, provided there is a stable relationship between the internal and the external labour market, forecasts may be made of future job vacancies. The specification of the job vacancies will be based on observation of the jobs already occupied. Estimates of the number of vacancies will have to be made on the basis of an assumed relationship between the number of jobs and growth of the industry.

Obviously these kind of forecasts are essentially short-term forecasts. And even in the short term there appear to be disturbances caused by short-term fluctuations in the demand and supply conditions, which make any attempt to forecast liable to extreme difficulties. In the Netherlands almost all forecasts of job vacancy and unemployment figures have proved wrong, the actual figures being again and again a complete surprise. Intra-firm developments as well as developments on the external labour market may disturb the stable relationship between internal and external labour markets.

We cannot think of any enterprise which between now and 1980 will experience a permanently stable relationship. The conditions on the external labour market may change, for instance, because of an increase or decrease in opportunities offered by industries which compete on the same labour market. In the first case the entry requirements may have to be lowered, in the second case they may be raised. In both cases the actual job profiles will have to be changed in order to adapt to the new conditions.

In order to ascertain the future demand for labour in terms of specified job vacancies for some single industry such as the automobile or the machine tool industry, it will be necessary to know what will happen on the external labour market. The conditions prevailing in automobile and machine tool firms in a particular region will be decisive for the whole of the labour market conditions only if employment opportunities in the area depend exclusively upon these industries. It does not seem wise for trade unionists to assume in 1968 that the economic policies of the respective governments will not attempt to provide a greater variety of opportunities before 1980.

The way in which the external labour market influences the internal conditions makes it difficult to draw any conclusions about a particular enterprise or industry.

The difficulties involved in pursuing the industrial demand approach seem to be insurmountable from a practical point of view(1). In the next two paragraphs we will try to show that the problem of this approach is also insoluble from a logical point of view.

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(1) Statistical, mathematical and logical ways of reasoning have indeed advanced rapidly in recent years. We have been provided with a body of methods that makes it possible to use the limited knowledge we have wisely. It is, however, usually overlooked that none of these methods adds to our information or takes away any uncertainty where there is no information.

In the discussions on the problems of manpower adjustment to technological change, suggestions have repeatedly been made that it would be possible to arrive at a notion of the direction of change by means of a time series of observations of the occupational structure.

We know that any structure may be seen as the compound results of the interplay of demand and supply on the labour market. We will therefore continue our considerations of how this interplay affects the occupational structure. We will also try to find a measure for the direction of change.

We defined the subjective job profile as the actual job profile that can be ascertained from the observation of what some particular worker is actually doing at some point of time. We chose the terms "subjective" in order to stress the contribution made by the particular worker's qualities. If we look at any subjective job profile we will generally discover a difference between this profile and the formal profile. We will call this difference the subjective differential. If we look at a subjective job profile at two different points of time we will generally discover that it has changed. In fact we will have to speak of two different profiles. The difference between these two profiles indicates the direction of the subjective differential.

We will speak of a positive direction if the actual job profile shows a higher level of skill mix than the formal profile and of a negative direction in the opposite case. We will speak of a horizontal direction if the actual job profile shows a skill mix which differs from the formal profile in content but not in level of skill required.

The change in the subjective job profile may be due to several reasons. The content of the job duties themselves will gradually change. The worker may become more experienced or as time passes he may gradually lose his skill.

The employer will either continuously or at regular intervals study the work organisation and see how it may be improved by internal transfer of workers, by a reshuffling of job duties, contracting or expanding the content of jobs.

Any subjective job profile is nothing more than a snapshot out of a time series.

Labour analysts of the A.N.M.B. suggest that an examination at intervals of a year would in most cases be sufficient to ascertain any changes.

The actual job structure of an enterprise or industry will be given by the complete set of subjective job profiles. Since these profiles are liable to continuous change the actual job structure will also show a continuous change.

The formal job structure of an enterprise or industry being given by the complete set of formal job profiles, the worker whose subjective differential becomes too large may, in terms of the formal job structure, be upgraded or downgraded or moved horizontally according to the direction of the differential.

The formal job structure may itself be changed if too many subjective differentials become too large, the direction of the change being determined by the direction of the differentials.

A group of subjective differentials can have the same direction. This may be due to several reasons. In conditions of more than full employment, for instance, the employer might lower the entrance requirements in order to spread his recruitment activities over a larger part of the labour market. In the opposite case he might raise the requirements. If the formal job structure remains unchanged this will give rise to negative, or positive, differentials for the newly recruited workers. If the employer thinks that the full employment (unemployment) situation will remain, then he might change the formal job structure. In that case there will only be a small differential for the newly recruited workers, but there will be positive (negative) differentials for the workers already employed. Expansion of more than one differential in the same direction may also occur because of a change in the methods of training for the kind of jobs concerned. Assuming that the new methods of training result in a higher level of skill, the worker who attended the new course will have an advantage over the worker who did not, and he will for that reason feel entitled to a higher wage. It will pay the employer to give the higher wage if a new and more valuable combination of job duties can be found which conforms better to the abilities of the newly trained person.

As more and more of the newly trained workers enter employment, the formal job profile will have to be adapted to the changed circumstances. The new formal structure will, as before, serve as a basis for the wage structure as well as for the purpose of defining job vacancies. Before the change of the formal structure, the newly trained workers had a positive differential, as the formal job structure reflected a situation which no longer existed. After the change, the newly trained workers will fit into the new formal job structure and their subjective job profiles will be pretty close to the new formal profiles.

The idea of direction that we can get from making a series of observations is rather unreliable. As soon as the direction tends to become clear the measuring-instrument itself will tend to disappear. The concept is, however, useful for analytical purposes and it will enable us to arrive at some preliminary conclusions, which will be dealt with later.

In most countries we will be able to find some information concerning the past. We are all convinced, for instance, that there has been a relative decline in the number of blue-collar workers as compared with white-collar workers.

It is most commonly assumed that this decline has been caused by technological development which caused the contents of job duties to change. On the assumption that this technological development will continue, we arrive at the conclusion that in the future there will be a further relative decline in the number of blue-collar workers. This may be true, but we must admit that past information supplies no evidence for this assumption. It is true that past information indicates the direction of the change but there is nothing in it to indicate the causes of the change.

Information concerning "what causes what" can only be derived from theoretical knowledge. As a matter of fact most of the theories used in forecasting our economic future have been produced by economists, whose main fault has been to suggest too strongly that technological change should be treated as an independent variable in their models. Closely related to this fault has been the lack of clear statements about the fact that none of the existing dynamic theories of economic growth is advanced enough to be applied for practical purposes.

Many complaints have been made about the lack of relevant statistical data, but the reasons for failures in forecasting lie more in a lack of theoretical knowledge about how these data interrelate. The lack of theoretical knowledge prevents us from drawing meaningful conclusions about the origin of past transformations, and the shape of future ones.

It would be interesting to drop the assumption that technological change is an independent variable. We may then, for instance, assume that the number of white-collar workers increased because that was what the workers wanted. The industries will then have responded by creating more job duties which can be combined into white-collar jobs. The change in the job duties would then represent a technological change which in itself was a response to changing supply conditions on the labour market. There is some evidence that something like that might have been the case. We all know the argument that labour saving innovations have been promoted by rising wages. Why then should there not have been similar responses to other changes in labour supply conditions. Most of today's white-collar workers in the Netherlands did not decide on that themselves. It was their parents who took this decision a long time ago and they did not base their decision on long-term forecasts but on their own past experience.

The committee that studied the situation in the Dutch shipbuilding industry in 1965 mentioned industry's lack of response to the changing supply conditions on the labour market as one of the factors that caused the difficult situation in this industry. The committee then recommended some intra-firm changes which might lead to an adaptation of the demand for labour.

A plant in Limburg had to start with a labour force consisting exclusively of redundant miners and had to frame its job profiles not only to adapt to these workers' specific qualities but also to permit the payment of wages which would not fall too far behind the relatively high wages to which they had become accustomed in the mining industries. As one manager said, "it was not easy, but in my opinion it turned out to be a complete success". As the trade unions concerned know, the only failure was not the fault of the firm, but of the forecasts of which workers would become redundant, in what numbers and from which sites.

Thus although some technological change should be considered as autonomous, some of it may have been caused by changing supply conditions on the labour market. In the same way there may have been some changes forced upon labour by autonomous technological change, but there may also have been some autonomous change in the supply conditions of labour which in the short term made for changing job profiles and in the long-term for changing contents of job duties. So our conclusion must be that not much can be said about the way in which technological change affects job profiles.

In the short term the job duties will be conditioned by the existing industrial apparatus, but the way in which they are combined into jobs of specific job profile will depend upon the employers' responses to the relevant labour supply conditions. In the long term, job duties may be changed in either direction in response to influences as yet unknown(1).

In the very short term, only the job profiles of existing jobs may be used as an approximate description of job vacancies, subject however to the condition of stable relationship between the internal and the external labour market.

The uncertainty of the future will have to be faced and cannot be replaced by forecasting methods which may only predict the facts of our own fiction. The only wise guideline for vocational education seems to be the one that starts from what we really know and all that we know is that we do not know anything real concerning the future. So our education should be directed towards armouring our youngsters against uncertainty.

We are asked to consider the most desirable training systems for youngsters in terms of the demands likely to be made on them by the work in the automobile and machine tool industries in 1980, i.e. to consider the most desirable training systems in terms of job vacancies open to them in these two industries in 1980. The position which we want to defend at the seminar is that the demands of neither industry in 1980 can be defined in terms of job profiles, unless we know exactly what

(1) One would like to ask whether we cannot make wise assumptions concerning these influences. It cannot, however, be sufficiently emphasized that it is not enough to ascertain these influences. The way in which management and labour respond to these influences will have to be forecast as well and it is our point that these forecasts cannot be made for lack of dynamic theories.

workers will be put in, what these workers' qualities will be, what training they will have had, what decisions will be taken by management because of these facts, etc.

This position amounts to a rejection of the industrial demand approach as referred to in paragraph 3. The industrial demand approach should be used exclusively for jobs which can be determined solely by the character of the job duties and for which in addition a unique relationship can be established to some more or less predictable factor.

The future need for doctors for example has been ascertained in some countries by the estimated growth of population on the one hand and the number of inhabitants to be served by one doctor on the other hand. For most of the lower and intermediate ranks of jobs, however, the industrial demand approach calls for a forecast of the combined results of some changes in job duties and some change in vocational education in order to be able to establish a vocational education by which these results can be realized. This puts the problem in a way which makes it insoluble both from a practical and from a logical point of view.

We said previously that some preliminary conclusions can be drawn by making use of the concept of direction that we defined in that paragraph. We recall for that reason what happened with the subjective differentials in case of unemployment.

We may conclude then that if there is not full employment, job profiles will call for higher levels of skill. If there is a surplus of labour it will pay employers to raise the entry requirements. This will affect the internal labour market. Those who were already employed and had small positive differentials, zero differentials or negative differentials at that time, run the risk of being downgraded in terms of the formal job structure. If employers think that the supply conditions of labour have changed definitively they will adapt the formal job structure to this new situation and there will be more downgrading.

What happens can be compared with what happens in a percolator. Job duties will be reshuffled until the workers with the lowest level of skill will become unemployed. The average level of skill in the new job profiles will have risen compared with the old profiles, the level of skill of the unemployed will be relatively low. Rapid technological change tends to speed up the obsolescence of the existing industrial apparatus which may cause the start of unemployment. If the economic structure of the country cannot absorb these kinds of frictions sufficiently quickly the percolator may start working, raising the level of skill required by industry and at the same time making up for a very hard core of low skill unemployment.

Thus we may predict that if there is rapid economic growth accompanied by many innovations, the level of skill required by industry will increase, unless the economic structure possesses the means by which full employment can be permanently maintained. In the latter case, the level of skill required will adapt itself to the level of skill offered. If our economic policies were inadequate we would run into unemployment no matter what our training policies were. With satisfactory economic policies, in particular those policies based on a correctly conceived definition of economic growth(1), we would be able to improve our training systems without running the risk of being repeatedly disturbed. We could make proper allowance then for the fact that it is only the gradual changes in the training systems which will be absorbed correctly by the social and economic structure of our society.

The industrial demand approach being rejected, the only way left seems to be the social demand approach. The case for this approach, however, is not much better. Apart from the more democratic character of this approach, the results of it will not differ very much from those which may be obtained by the industrial demand approach, because in both cases the decisions taken will be based upon past experience. The workers' aspirations run for the greater part in terms of some formal job structure which has lasted long enough to have become generally known - and which for the same reason will be rather obsolete as well.

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(1) The continuous reshuffling of workers within a continuously changing job structure regardless of the kind of jobs they would like most, may involve such losses in their well-being that we may certainly feel allowed to express serious doubt about the justification from a social as well as from an economic point of view of the policy-aims concerning rapid economic growth.

PROSPECTIVE JOB PROFILES IN THE AUTOMOBILE AND MACHINE TOOL INDUSTRIES IN 1980

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The bridge between man and his job is complex and intricate. It is a bridge which is influenced by many factors, and to speculate as to its precise configuration 12 years in advance is indeed a difficult task. What specific job profiles will be in the automobile and machine tool industries in the year 1980 will reflect in part some of the trends we have witnessed in the past 15 years. However, we do know that job profiles change, and that they change for many different reasons.

The source or the thrust of the change may vary from time to time, both as to intensity and persistency. While we are in a position to note the trends of the past, it would be foolhardy to overlook or disregard those important institutional factors that are constantly at play which constantly determine what makes a "job a job". They will continue to have an impact on the "job design" of the future, and it is quite possible, given the vast social changes that are occurring, that they will not react or behave as they did in the past.

Planning vocational school courses for metal working occupations 12 years hence, of necessity involves many variables. We are on the threshold of an era where machines can be and are designed in accordance with the ability and skill of the human operator and his attitude towards work. His attitude towards work and the particular job he is performing is the product of the interaction of many forces, including the state of technology at any one period of time, the general level of economic activity in the country, his educational attainment, his concept of himself in society, his relation with his union, and his mobility (both social and spatial). There are others, but these are the most important insofar as affecting his general attitude towards work and the job he occupies. His attitude towards work, as such, does influence the character and nature of the job profile - simply because he does have a voice in how that profile will be designed. While time does not permit an exhaustive, detailed examination of each of these factors, I have briefly reviewed certain of them and attempted to speculate as to how they may affect future job profiles.

1. Concept of Man in Society

Where at one time the Protestant work ethic characterised most working people in the United States, there is significant evidence that individuals are no longer adhering to this ethic as they did in the past. For years, it was considered "sinful not to work". Today, however, there are tremendous pressures within the American society to emphasize leisure, recreation and cultural pursuits. This has been made possible because of higher wages and shorter working hours. To some extent, these two goals - work and leisure - reinforce themselves. That is, one seeks work, not because "work" is in and of itself something virtuous, but it is a means to greater leisure, and hence, one may enjoy greater recreation and cultural pursuits. This attitude is somewhat different from that which characterized the 19th and early 20th Centuries, and while it represents a trend, it is by no means uniform through the economy. Further, it should be stated that there are many who still lack the necessities of life as such. Theirs is not a seeking for leisure, but for the basic needs of surviving.

This change of attitude towards work has affected the individual's attitude towards his job. For example, the individual's willingness to "move with the job" in instances where he is transferred or in cases where the entire plant is moving to a new location, is far greater than years ago. Similarly, his willingness to move to find a job today is much greater than previously.

His attitude - either expressed individually or through his union - to co-operate at the work place to increase productivity - is far different from earlier years. He feels somewhat assured that the fruits of his increased productivity will be shared with him through the process of collective bargaining.

He is further assured that if he is displaced, transferred or is otherwise temporarily unemployed because of technological changes, certain benefits will be forthcoming to ameliorate the economic hardships involved. While there is still the fear upon the part of the individual of being jobless, this fear is more greatly shared with society than previously. Unemployment - be it temporary or permanent - is viewed as a social problem that requires the attention of government. Where at one time it was considered the fate of the individual, it is now a concern of society as a whole.

In summarizing, the individual's attitude towards his work in the years to come will be more thought out. A job will be more than a means of earning a living. While he will continue to insist on what he considers to be his share of the increased wealth of the nation - in terms of higher wages and greater leisure time - he will also better prepare and better integrate himself with the needs of the employer. He will have a concept of his "job" and how it should be performed, but at the same time, he will have a greater understanding and comprehension of himself in relation to his fellow workers and the status of the employer.

He will have viewed the vast social mobility that has occurred, and he will not see himself as a static object; he will have a greater propensity to make the necessary adjustments required by "work" vis-à-vis education, mobility in order to achieve the higher pay, the more meaningful job, the more provocative challenge. He will not be a bystander.

2. Role of the Trade Union

The two industries being studied have been organised for many years by three dominant labour organisations. They are the United Auto Workers, the United Steelworkers and the International Association of Machinists and Aerospace Workers. While their specific policies may vary slightly as to the "ideal concept of what a job should be" it is important to note that the policy of organised labour towards the design of a job is extremely important. Organised labour has always considered this as a bargainable issue, and the perimeters and specific combination of functions of a job has long been and presently is a subject discussed in most negotiations. How a job is designed will to a certain extent determine the rate of pay for that job, and what is just as important, determine the number of individuals who would be eligible to be classified in that job. To purposely over-inflate the requirements of a job will intentionally limit those who would then become eligible for promotion to that job. Therefore, there is a "dynamic" concept in play of balancing - through negotiations - the ever-increasing skills of the individuals with the changing requirements of the job.

If a labour organisation sought, as a matter of policy, to fragment and dilute jobs, the design and composition of most jobs would be radically affected. Similarly, if as a matter of policy, a labour organisation sought to "broaden jobs", they would seek to incorporate more duties, and hence create a more flexible and versatile work force.

The experience of the past 20 years has served to re-emphasize that which many unions have known for years. The least skilled individuals are more apt to be unemployed and have the most difficulty in securing alternative employment if laid off. Similarly, the individual with the greater skill is the more flexible and can adapt to changing requirements if so needed. There is substantial evidence that organised labour is seeking to broaden jobs, to incorporate more duties, and to provide training programmes or progression systems to achieve eligibility for those who are seeking the higher paid jobs.

During the period of World War II when over 10 million of the work force were in military service, it was necessary to dilute and fragment jobs in order to secure the necessary production. The trend is now in the other direction, except for those hard core unemployed who are gradually entering the work force. In some instances, it has been necessary to fragment entry jobs to enable these people to acclimatize themselves to the "world of work". However, this will be limited to entry jobs, and then for only certain individuals. Once they have accomplished this challenge, they can progress as others.

Coupled with the efforts to broaden jobs, and hence broaden seniority, is the effort to regain representation rights for work now being performed by non-represented technical, sub-professional and professional employees. Because of the new technologies, processes, materials, etc., the technical classifications created by management to perform much of this work were placed outside the scope of the bargaining unit. For example, in many industries, the number of individuals in this category has increased from 50 to 100 per cent in the past 15 to 20 years. Efforts are now being made to recapture this work, and to represent the workers in these technical and sub-professional classifications.

Many of the workers in these technical and sub-professional classifications were promoted from the union ranks - that is, from the bargaining unit. There is tremendous mobility within the hierarchy of jobs with a particular plant. Further, there is a substantial movement of individuals between jobs represented by the union and those in the technical and sub-professional jobs outside the scope of the unit. This is reflected in the fact that many apprentices today are, within five years after graduating, recruited into the ranks of supervision. Management has found that much of the training experience by the unions is much better for certain supervisory jobs than training afforded by institutions. Not only is this true of the technical aspects of a trade apprenticeship, but it is also true of leadership capabilities of trade union officials. The selection of foremen and assistant foremen is often from the ranks of union stewards and union committee men.

In summarizing, one can conclude that unions will seek (a) to broaden functions of jobs, (b) to facilitate mobility within the job hierarchy, and (c) to participate, encourage and endorse apprenticeship and training programmes, and seek to update and upgrade existing skilled and technical classifications.

The ability of a union to represent workers is somewhat correlated with the skills the individual members possess. The greater the skills the more inherent bargaining power the union has.

3. Education

The educational attainment of the work force by 1980 will be a principal determinant as to how jobs will be designed. Further, this attainment will also reflect itself in how the individual may view the job he is requested to perform. The capability of the individual to accept and absorb the increased requirements of a rapidly changing technological era will be determined by the years of school he has completed, including elementary, high school, vocational school, and college.

While the projections of the United States Department of Labour are limited to 1975, it is very apparent that tremendous strides are being made in raising the average education of the work force.

For the period 1959-1975, it is expected that those having less than 8 years of schooling will be more than halved. For this same period, those completing 4 years of high school will increase 42 per cent, and those completing college will increase 50 per cent.

Years of school completed	March 1957-59 average	March 1964-66 average	Projected 1975
Total	100.0	100.0	100.0
Less than 4 years of high school	53.7	45.1	34.0
4 years or more of high school	46.3	54.9	66.0
Elementary : 8 years or less	34.5	26.2	16.0
High School: 1 to 3 years	19.2	18.9	17.9
4 years	27.8	32.8	39.5
College : 1 to 3 years	8.4	9.6	11.1
4 years or more	10.2	12.5	15.4
Median years of school completed	11.4	12.2	12.4

It is quite apparent that by the year 1980, a very small portion of the labour force will have had less than 8 years of schooling. If the pre-1975 trend persists, over three-quarters of the work force will have had 4 years or more of high school in the early 1980's.

Coupled with this trend for securing greater formal education is a similar effort in the field of vocational education.

Total Enrolment in Vocational Education
Fiscal Years 1960-1967

Fiscal Year	Total Enrolment	Percentage Increase
1960	3,768,149	
1961	3,855,564	2.3
1962	4,072,677	5.6
1963	4,217,198	3.5
1964	4,566,390	8.3
1965	5,430,611	18.9
1966	6,070,059	11.8
1967	6,880,000*	13.3

*Projected

Source: United States Department of Health, Education and Welfare

No projections have been made beyond the dates shown, but evidenced by the willingness of the Congress and the individaul states to appropriate funds to finance these programmes, it is fair to assume that there will be over 15,000,000 enrolled in vocational schools by 1975. From 1964 to 1966, total expenditures increased about two and a half times (from $332.7 million in 1964 to $799.9 million in 1966). Federal grants to the states rose over four times, and state and local expenditures doubled.

In addition to the formal and vocational school programmes under way, a vast number of federally financed institutional and on-the-job training programmes are being instituted. These reflect primarily the efforts to solve the problems of hard core unemployment, and secondly, to update and upgrade the skills of our work force to meet the new demands of technology. During the last 6 years, a vast new awareness of the manpower problems in our economy has developed - and there is no question that a greater share of our national resources is being devoted to resolving many of these problems.

As evidenced by the following table, appropriations for federally supported manpower programmes, including vocational school expenditures, have increased almost ninefold from 1961 to 1967:

APPROPRIATIONS FOR FEDERALLY-SUPPORTED MANPOWER PROGRAMMES-FISCAL 1961-1967

Programme	1961	1967
Total	275	2,149
Labour - United States Employment Service	152	306
Bureau of Apprenticeship and Training	4	8
Bureau of Labour Statistics (Manpower and Employment)	4	9
Manpower Development and Training	-	421
Health, Education and Welfare - Vocational	50	283
Education, Vocational Rehabilitation	75	313
Office of Economic Opportunity - Neighbourhood Youth Corps	-	325
Job Corps	-	211
Work Experience	-	100
(1) Other O.E.O. Manpower	-	143
(2) Adult Basic Education	-	30

(1) Estimated
(2) The 1966 amendments to the Economic Opportunity Act transferred funding of Adult Basic Education to the Department of Health, Education and Welfare.

It is not possible here to discuss why the American people are so much more concerned about questions of manpower, but this concern will certainly have a very marked effect upon the educational attainment and educational capability of our work force in 1980.

4. Level of Economic Activity

It is anticipated that by 1975, our population will have reached 224 million. In effect, the birth rate will increase from 19.7 per thousand in 1966 to 23.8 per thousand in 1975. With this growth in population, the labour force will number nearly 94 million in 1975, and the rate of participation in the labour force will have increased over 1 per cent by that year. This will be as a result of greater numbers of women and teenagers in the work force.

Average hours of work will continue their downward trend, and by 1975, the average **work-week will decline to 38.5 hours.**

Where on one hand, employment will increase at a faster rate than in recent years, on the other hand, hours worked per week will decline at a faster rate.

During the next 8 to 10 years, we will see a high rate of investment in capital equipment. Rapid technological change will speed obsolesence and necessitate rapid replacement of capital goods.

In 1965, approximately $21 billion was spent on research, and it is anticipated that this will be more than doubled - $45 billion - in 1975. In 1965, capital stock averaged $11,500 per worker; by 1975, this will have increased to $16,400. This will occur because of the increased growth in productive facilities and the decrease in the average age of productive equipment. As indicated above, not only will the capital stock grow absolutely, but its composition will be of increasingly newer productive units.

It is anticipated that by the middle or late 70's, we will have achieved a steady productivity rate in excess of 3 per cent per year.

From all of the indications, the United States economy will be operating at nearly full capacity, with perhaps a 3½ to 4 per cent rate of unemployment. Under these circumstances, namely, a tight labour market, individuals and unions will have a greater voice in the determination of the design of the job.

5. Technology

It is impossible to discuss changing skill requirements and job profiles in the metal working industry without briefly touching upon some of the major technological changes taking place in the industry. The degree to which the content of jobs in this industry will be changing is directly related to these advanced production techniques.

Numerical Control

Numerical control (N/C) is probably the most significant new development in manufacturing technology since Henry Ford introduced the concept of the moving assembly line. The most common application of N/C is in the control of metal cutting machine tools. N/C enables the machine tool itself to perform most of the functions that are done by the machine operator on conventional machine tools.

Sales of N/C metal working machinery in 1967 reached $285 million, or 15.2 per cent of total sales. It is estimated that some 12,000 N/C machine tools were in operation in the metal working industry at the end of 1967. Various industry sources have estimated that by 1970, approximately 75 per cent of all machine tools purchased will be equipped with numerical control.

The next generation of N/C machine tools will be based on the concept of the self-contained machining centre, i.e., a machine tool or family of machine tools able to perform all the machining operations required to complete a part. At last count, 114 of these machining centres were in use in the metal working industry. By 1975, one-third of the N/C metal cutting machine tools purchased are likely to incorporate this concept.

N/C is quickly finding applications in other areas of metal working manufacturing. For example, continuous path N/C is being used for flame cutting operations, spot welding of fabricated sheet metal parts, in piercing rivet and bolt holes in structural steel members, and in cutting coils of metal into sheets of various lengths. The next 5 to 10 years will see rapid development of semi-standard units that can be adapted to specific assembly and transfer tasks through the attachment of various part-holding devices and special manipulative devices.

The electronics industry represents one of the most fertile fields for N/C machines because of the tremendous variations that exist within a given product line and the high degree of reliability required. A recent Aerospace Industries Association report predicts that by 1972, some 60 per cent of the printed circuit board produced for aerospace use will be fabricated and assembled by N/C equipment.

N/C may even provide one solution to shortage of design engineers and trained draftsmen in industry. Numerically controlled drafting machines can produce precise drawings from programme instructions developed from mathematical equations. N/C inspection is found in the aerospace industry where needs for close tolerances and complex shapes necessitate that human error be minimized in inspection.

Electronic Metal Working Processes

Missile and space programmes have necessitated the use of various exotic materials and super-alloys which are, at best, difficult to machine or form by conventional techniques. To resolve this problem, systems have been developed for metal working processes based on electronic principles. Several of these new electronic metal working processes are likely to supplement and, in some cases, displace conventional metal working techniques in some industrial applications. The impetus of further development of these technologies in the immediate future will, no doubt, continue to come from the aerospace industry. By 1980, however, electronic metal working processes are expected to play an important role in manufacturing operations in certain areas of industry generally.

What are a few of these new processes? One is Electrical Discharge Machining (EDM). Instead of cutting with a bit, this tool uses electric sparks to vaporise the metal in its path. Because it can maintain close tolerances, EDM is expected to have particularly important impact on the tool and die industry.

Another new process is Electrochemical Machining (ECM). In drilling, for example, this process uses electrolysis to "pull out" the metal from the holes. There are about 500 electrochemical machining installations in the country. About $16 million of this equipment was sold last year and the market is expected to reach $30 million annually by 1970.

Electron and laser beam welding, two more outgrowths of aerospace programmes, are expected to find wide industrial applications. Electron beam welding involves the use of a tool which emits a sharply focused beam of high energy electrons that melts the edges of metal to be joined as it passes along the joint. The metal resolidifies in the wake of the beam, forming a smooth, strong weld. Currently, about 450 tools are in operation. The automotive industry is currently experimenting with electron beam welding, and may find it of considerable value in producing components for gas turbine engines.

Laser beam welding employs a beam of light as a source of welding energy. One problem in welding with laser, however, is that the intense beam of light they emit tends to boil away metal at the intended joint if not extremely carefully controlled. But precisely because the beam is so concentrated, lasers can weld delicate electonics parts without deforming them.

Magnetic metal forming, at its present level of development, is restricted to applications involving thin, non-magnetic materials. As a result, magnetic forming is expected to supplement rather than displace conventional metal forming techniques. The process involves the forming of metal with jolts of magnetic pressure. Such operations do not involve heat and, therefore, can be used near explosives, rubber or plastic where ordinary welding would not be safe. Also, it eliminates some precision machining, because parts can be fitted loosely, then clamped together magnetically. Finally, it is a clean, dry process that does not mar finishes and eliminates subsequent cleaning and polishing.

These are just a few of the "exotic" processes which will transform the metal working processes. The percentage of materials removed by improved conventional metal working techniques is expected to decline from 85 per cent to 70 per cent between 1962 and 1972. Unconventional processes, correspondingly, will gain, rising from 15 per cent in 1962 to 30 per cent by 1972 - and the electronic processes are expected to account for more than half of this increase.

In addition to the technological changes which I have mentioned here above, there are also radical changes in metal forming, assembly, erection, cutting, and in many other fields. It is anticipated that technological developments will continue to occur in future years, and it is nearly impossible to describe in detail the precise results of these developments. Nonetheless, they are certain to affect job profiles of individual metal working occupations, and also to affect the relative number of these occupations in the total labour force.

Given the decentralized administration of our apprenticeship and upgrading programmes local plant committees are in a position to adjust the curriculum to apprenticeship programmes, and to intelligently update curricula for bringing the skills of traditional crafts into today's needs.

As new developments occur, we feel somewhat assured that proper adjustments will be made to established apprenticeship and training programmes to be certain that the apprentice will have adequate opportunity to learn the new processes.

Profiles of Jobs in the Machine Tool Industry

The machine tool industry is considered to be only one segment of the machinery industry (except electrical), and represents approximately 18 per cent of total employment in the machinery industry. At the close of 1966, there were 335,500 workers employed in this industry, and approximately 76 per cent of them were production workers. It is an industry characterized by severe ups and downs, and very much affected by the accelerated depreciation tax laws often used by the government. In essence, when an employer can accelerate the write-off of a machine tool, he is apt to replace the older machine tools in his factory. In 1963, 64 per cent of the metal cutting machinery was 10 years old, and 20 per cent of these machine tools were 20 or more years old. It is fair to assume that, should the accelerated depreciation tax law remain in effect, activity in this industry will continue at a high rate.

While some increase in employment in this industry is expected, particularly because of the increased demand for numerically controlled machine tools, many of these orders will merely replace conventional machine tools. It is anticipated that by the mid-70s, over 70 per cent of the metal cutting and metal forming machining will be performed by numerically controlled machine tools.

As regards projected increases in the various occupations within this industry, it is expected that the professional and technical occupations - which now represent approximately 10 per cent of the total - will increase two-fifths by the late 70's. There will be an increase in engineers, programmers and technicians at the expense of skilled and semi-skilled tool operators. The number of labourers will decline by approximately one-third, because of the increased use of new, efficient material-handling equipment, and automatic transfer devices. Because of the increased application of instrumentation and computer control, there will be a decrease in the proportion of inspectors and machine tool operators, but some increase in instrument repairmen, machine repairmen, and the like.

Table 1 sets forth the distribution of employment in the machinery (except electrical) industry, by occupation, 1960 and projected 1975. These statistics will be published in the very near future by the Bureau of Labour Statistics, and were compiled only after years of intensive study. The 1960 figure represents a trend which occurred prior to that year, and it is the definite opinion of the managers of industry that the trend expressed in comparing 1960 with 1975 will continue beyond 1975 into the future.

Table I

Distribution of Employment in the Machinery (except Electrical) Industry, by Occupation, 1960 and Projected 1975

Occupation	1960	Projected 1975
Total	100.00	100.00
Professional, technical, and kindred	10.34	14.65
Engineers, technical	4.38	5.69
Engineers, aeronautical	.01	.01
Engineers, chemical	.05	.04
Engineers, civil	.06	.03
Engineers, electrical	.43	.73
Engineers, industrial	.61	.87
Engineers, mechanical	2.01	2.34
Engineers, metallurgical	.10	.10
Engineers, mining	.01	.00
Other engineers, technical	1.11	1.59
Natural scientists	.28	.40
Chemists	.08	.09
Mathematicians	.10	.17
Physicists	.06	.09
Other natural scientists	.04	.04
Technicians, except medical, dentist	3.42	4.66
Draftsmen	1.92	2.26
Technicians, other	1.49	2.40
Medical, other health workers	.09	.13
Dieticians, nutritionists	.00	.10
Nurses, professional	.07	.09
Physicians and surgeons	.01	.01
Psychologists	.00	.01
Technicians, medical, dental	.01	.01
Teachers	.02	.02
Teachers, other	.02	.02
Social Scientists	.06	.05
Economists	.04	.03
Statisticians and actuaries	.02	.02
Other professional, technical, and kindred	2.08	3.69
Accountants and auditors	.79	.89
Airplane pilots, navigators	.02	.03
Workers in arts, entertainment	.14	.19
Designers, except design draftsman	.28	.28
Editors and reporters	.04	.06
Lawyers and judges	.02	.02
Librarians	.01	.02
Personnel & Labour relations workers	.20	.25
Photographers	.05	.05
Professional, technical, & kindred, n.e.c.	.53	1.91
Managers, officials, proprietors	6.57	7.88
Creditmen	.06	.08
Purchasing agents	.54	.63
Managers, officials, proprietors, n.e.c.	5.97	7.17
Clerical and kindred workers	13.32	12.57
Stenos, typists, secretaries	3.52	3.93
Office machine operators	.71	.90
Other clerical, kindred workers	9.09	7.74
Accounting clerks	.53	.36
Bookkeepers, hand	.45	.36
Cashiers	.04	.02
Shipping, receiving clerks	1.13	.94
Telephone operators	.12	.12
Clerical and kindred, n.e.c.	6.83	5.95

Distribution of Employment in the Machinery (except Electrical) Industry, by Occupation, 1960 and Projected 1975 (Cont'd)

Occupation	1960	Projected 1975
Sales workers	2.28	2.34
Craftsmen, foremen and kindred	27.90	25.14
Construction craftsmen	1.20	.98
Carpenters	.22	.12
Brickmasons and tile setters	.03	.03
Electricians	.59	.50
Excavating, grading machine operators	.02	.01
Painters and paperhangers	.05	.04
Plasterers	.01	.01
Plumbers and pipefitters	.25	.24
Structural metalworkers	.04	.04
Foremen, n.e.c.	3.77	4.52
Metalworking craftsmen except mechanics	17.42	13.56
Machinists and related occupation	11.13	7.93
Blacksmiths, forgemen, hammermen	.16	.10
Boilermakers	.03	.02
Heat treaters, annealers	.33	.29
Millwrights	.25	.22
Molders, metal, except coremakers	.57	.49
Pattermakers, metal, wood	.37	.30
Rollers and roll hands	.04	.04
Sheet metal workers	.60	.49
Toolmakers and diemakers	3.94	3.69
Printing trades craftsmen	.12	.11
Compositors, typesetters	.04	.03
Electrotypers, stereotypers	.01	.01
Engravers except photoengraver	.04	.03
Photoengravers, lithographers	.01	.02
Pressmen, plate printers	.02	.02
Transportation and public utilities craftsmen	.02	.02
Linemen and servicemen	.01	.02
Locomotive engineers	.00	.01
Mechanics and repairmen	3.58	3.60
Airplance mechanics and repairmen	.02	.02
Motor vehicle mechanics	.17	.12
Office machine mechanics	.36	.36
Railroad and car shop mechanics	.01	.01
Other mechanics and repairmen	3.02	3.08
Other craftsmen and kindred	1.78	2.35
Cabinetmakers	.03	.00
Crane, derrick, hoistmen	.44	.42
Jewelers and watchmakers	.01	.01
Inspectors, other	.02	.01
Upholsterers	.06	.05
Craftsmen and kindred, n.e.c.	1.23	1.84
Operatives and kindred workers	35.12	34.34
Drivers, other transportation & public operator	.70	.68
Drivers, bus, truck, tractor	.60	.55
Deliverymen and routemen	.09	.11
Brakemen and switchmen, railroad	.00	.01
Power station operators	.01	.01

Distribution of Employment in the Machinery (except Electrical)
Industry, by Occupation, 1960 and Projected 1975 (Cont'd)

Occupation	1960	Projected 1975
Semi-skilled metalworking occupations	18.09	17.12
Furnacemen, smeltermen, pourers	.20	.17
Heaters, metal	.02	.02
Welders and flame-cutters	3.32	4.48
Assemblers, metalworking, class A	2.12	2.27
Assemblers, metalworking, class B	4.76	4.90
Inspectors, metalworking, class B	1.44	1.25
Machine tool operators, class B	6.13	3.96
Electroplaters	.04	.02
Electroplaters, helpers	.06	.05
Semi-skilled textile occupations	.04	.01
Weavers, textile	.01	.01
Sewers and stitchers, manufacturing	.04	.00
Other operatives and kindred	16.28	16.53
Asbestos, insulation workers	.01	.00
Meat cutters, except meatpacking	.01	.00
Operatives and kindred, n.e.c.	16.26	16.52
Service workers	1.58	1.28
Protective service workers	.60	.36
Guards, watchmen, doorkeepers	.59	.36
Police, other law enforcement officers	.01	.01
Food service workers	.07	.06
Cooks, except private households	.03	.02
Counter and fountain workers	.02	.03
Waiters and waitresses	.02	.02
Other service workers	.91	.85
Attendants, hospital, other institutions	.00	.01
Charwomen and cleaners	.15	.16
Janitors and sextons	.53	.43
Service workers, n.e.c.	.21	.24
Labourers, except farm and mine	2.89	1.80

Note: Parts may not add to total because of rounding.

I have included these occupational projections, since they relate to the probable job profiles in 1980. When developing curricula for metal worker occupations consideration must be given to possible promotion to those other technical and sub-professional occupations. Many machinists, tool and die makers and skilled machine tool operators have been promoted to programmers and analysts, simply because of their knowledge of materials, cutting and forming processes, and the characteristics of machinery and machine tools. One could anticipate that their job profiles in the future will include more duties and responsibilities to facilitate their "bridging" the gap between their present metal working occupations and the higher technical and sub-professional occupations.

controlled machine tools, most employers will attempt to design their operations to secure maximum utilization of such a machine tool. In fact, this is recommended by many of the machine tool builders. In other words, time spent in setting up a job, checking tools, and inspection must be kept at a minimum in order that they may derive maximum cutting time. Accordingly, in many shops, the set up operation is performed by another person, along with the selection and checkout of all tools that are to be positioned in the machine for that job. The machine tool operator literally spends all of his time operating, while the tool setter delivers to the machine tool operator the already-set-up job, along with the necessary tools for that job.

I have included copies of job descriptions for five metal working occupations found in many machine tool firms. They are:

Milwaukee-matic III-V Numerical Control Machine Operator
Tool Setter - Numerical Control Machine Operator
Numerical Control Technician
Electrical Maintenance Technician
Machine Repair - Class A

I would like to comment briefly as to the prospective changes in the job profiles of these particular occupations.

Numerical Control Machine Operator

As evidenced by the description, this individual must be fully acquainted with the operation of the machine, set-up techniques, tool selection, and further, be able to prove tapes and correct errors that may occur. While he may appear to be only a "button pusher", in reality he is compensated for his stand-by skills. As indicated previously, because of the high cost of most numerical machine tools, they must be maximum utilization. While others may set up the job for him, check and select the necessary tools, he is responsible for the operation of that machine. The employee cannot afford to risk collisions which would damage that machine and reduce or terminate production. Accordingly, the operator must be knowledgeable about all facets of its operation to ensure continuous utilization.

As more sophisticated N/C machine tools are developed, he will be expected to be knowledgeable as to proper speeds, feeds, characteristics of materials, coolants, and so forth. He will no doubt be expected to have greater knowledge of mathematics, electronics and fluidics to properly monitor the operation. The managers of the machine tool industry do not foresee significant changes in his job profile resulting from changing technology, except to the degree of his knowing and understanding new developments in the construction and operation of machine tools as they occur. However, should management attempt to make this a pure "button pushing" operation - of which there is little likelihood - unions would drastically oppose such a move.

Job Description

MILWAUKEE-MATIC III-V NUMERICAL CONTROL MACHINE OPERATOR

Work is performed in the Major Parts Machining Area setting up and operating a Milwaukee-Matic III-V Numerical Control Machine.

Duties include: set up and operate Milwaukee-Matic machine automatically or manually. The Milwaukee-Matic III-V automatically performs a series of operations such as mill, drill, tap, ream, bore and counter-bore on parts such as columns, heads, knees and special work. Tolerances of 0.0002 inches to 0.0001 inches on boring 0.0005 inches for reaming, 0.0005 inches to ± 0.005 inches for milling are maintained. Check and inspect work while in process and after completion of the operation. Required to make adjustments to cutting tools to maintain size. Determine when cutting tools need to be replaced due to wear or to meet finish requirements and make the necessary changes. Operate machine manually including manual placement of tools in spindle and/or tool drum and shuttling platens as required. Prove out new tapes complete. Check out programmes and tooling on new jobs. Troubleshoot and overcome difficulties encountered in proving out tapes, tooling, machining operations and set up. Required to have a working knowledge of programming and control tapes. Use equipment such as fixtures, angle plates, holding devices, dividing heads and vises. Perform work of a lower classification. Work with ferrous and non-ferrous materials.

Required to use drawings with dimension and specifications. Mathematics include addition and subtraction of fractions and decimals and the use of handbook formulas. Use measuring instruments such as 0.0001 inches indicator, planer gauge vernier, Jo-blocks, size plugs, adjustable parallels, square, protractor, scale, surface gauge, telescopic gauges, dial bore gauges, inside, outside and depth micrometers.

Moderate physical effort required in handling light and average weight tools and materials and intermittent handling of fairly heavy weight tools and materials.

Typical machine shop working conditions, maybe slightly dirty and/or wet.

Tool Setter - Numerical Control Machine Operator

This is a combination classification, and the individual occupying this classification serves as a relief man for numerical control machine operators. His principal functions are normally tool setting, but in addition to this requirement, he is expected to operate N/C machine tools.

I would foresee that many individuals who are just classified as tool setters will attempt to broaden their classification to incorporate the operation of N/C machine tools also.

I do not visualize radical changes in the profile of the tool setter, except that it is very probable that the number of individuals holding this classification will markedly increase as more N/C machine tools are purchased. His knowledge of the proper use of tools and the operation of N/C machine tools will enhance his opportunities for promotion into the programmer classifications. In this regard, he will probably insist upon, and receive, some change in his profile to facilitate progression into certain of the technical and sub-professional classifications. This would involve greater knowledge of mathematics, communication, and some electronics.

Numerical Control Technician

As evidenced by the description, the individual, in addition to operating N/C machine tools, must assist in teaching others to operate and overcome difficulties which may arise. I would visualize that the occupations of this classification will increase in number as more employees are assigned to the operation of N/C machine tools. Similar to the operator, his profile will not change substantially in the years to come, unless there are radical changes in the design and operation of these tools.

Electrical Maintenance Technician
Machine Repairman

The maintenance of machine tools is divided between the Electrical Maintenance Technician who will handle all the electrical and electronic repair and troubleshooting, and the Machine Repairman who is responsible for the repair and troubleshooting of mechanical and hydraulic failures.

It is interesting to note that in some of the machine tool firms, individuals who are "sent on the road" to diagnose and repair breakdowns for those purchasing a particular type of machine tool, have both the mechanical and electrical/electronic skills. However, those working in the shop repairing these machine tools are divided into these two categories. It is probable that in the future, there will be some overlap - although not completely - between these two occupations. That is to say, the machine repairman will enlarge his knowledge of electrical/electronics, while the electrical maintenance technician will enlarge his knowledge of mechanical and hydraulic principles. This latter trend may be facilitated where both classifications are represented by the same labour organisation, as differing in many situations where the electrical maintenance technician may be a member of a craft union differing from the industrial union representing the remaining employees.

Job Description

TOOL SETTER - NUMERICAL CONTROL MACHINE OPERATOR

Work is performed in the Major Parts Machining Area as a Tool Setter setting cutting tools and operating numerical control machines part time as required.

Duties include: Use tool operation sheet and tool prints to set code rings on tool holders and to set cutting tools in holders; includes proper mounting distances and diameters to as close as ±0.0002 inches tolerances. Use special tool setting gauge, height gauge, indicators and micrometers to set tools such as boring bars, reamers, taps, milling cutters and counter-bores. Check cutting tools for size, runout, sharpness and condition. Required to set up fixtures and holding devices on platens which may require indicating for proper location and loading first piece. Tear down fixtures and holding devices. Disassemble tools and holders and maintain in proper storage area. Store tapes, programmes, tool sketches, tool list, coded part drawing files and tools and maintain department records. Required to have a working knowledge of tool grinding, machine shop operations such as milling, drilling, tapping, reaming and boring and the machining qualities of ferrous and non-ferrous materials. On a part time basis operate any numerical control machines automatically or manually after set up is completed and job is in operation. Load and unload workpieces and platens. Operate machine manually including manual placement of tools in spindle and/or tool drum and shuttling of platens as required. Make adjustments to cutting tools to maintain size and replace tools when necessary due to wear or to meet finish requirements. Check work being performed such as bore size and depth of a hole. No prove out of tapes of any kind new or altered is required. Use equipment such as fixtures, angle plates, vises and holding devices.

Use drawings and sketches with dimensions and specifications. Use shop mathematics. Measuring instruments used include; vernier height gauge, 0.0001 inches indicators, scale, square, dial bore gauges, tool setting gauge, inside outside, and depth micrometers.

Moderate physical effort required working with light and average weight tools and intermittent handling fairly heavy weight tools.

Typical machine shop working conditions.

Job Description

NUMERICAL CONTROL TECHNICIAN

Work is performed in the Major Parts Machining Area as a Numerical Control Technician. Under direction of the supervisor, includes assisting Operator - Numerical Control Machines - Class A and employees of lower classifications in overcoming difficulties encountered, instructing employees in the use of numerical control machines and department equipment and assist in following the prescribed plan in allocating work to the employees.

Duties include: Set up and operate numerical control machine ##II and other equipment or machines in the area, operate numerical control machines automatically or manually. Numerical control machines automatically perform a series of operations such as mill, drill, tap, team, turn, bore and counterbore. Work on parts such as cross feed brackets, pump bodies, speed boxes, feed boxes, table brackets, spindle rotary feed box, hydraulic manifold, control valve body, gears, shifter levers, a variety of brackets and housing and special work. Tolerances of 0.0002 inches to 0.001 inches for boring, 0.0005 inches for reaming, and from 0.0005 inches to ± 0.005 inches for milling operations are maintained. Operate machine manually including placement of tools in spindle and/or tool drum and shuttling platens as required. Check and inspect work while in process and after completion of the operation. Required to have a working knowledge of programming and control tapes. Prove out new tapes complete. Check out programmes and tooling on new jobs. Use equipment such as fixtures, angle plates, holding devices, dividing head and vices. Work with ferrous and non-ferrous materials. Under instruction or direction of the supervisor performs the following: make minor repairs and adjustment to maintain jigs, fixtures and tooling; allocate work by following a prescribed plan; help overcome difficulties encountered in set up, tooling and in performing operation of Operator - Numerical Control - Class A or lower classified employees, aid and instruct employees in the safe and proper use of machines and equipment, job techniques and in the standard routines and procedures used. Work with new equipment and assist in working out operational methods and procedures. Perform work of a lower classification.

Use complicated drawings with many dimensions and specifications. Use advanced shop mathematics. Use measuring instruments such as 0.0001 inches indicators, tool setting gauge, planer gauge, vernier, Jo-blocks, size plugs, adjustable parallels, protractor, scale, surface gauge, telescopic gauges, air gauges, dial bore gauges, inside, outside and depth micrometers.

Light physical effort required performing job duties.

Typical machine shop working conditions.

Job Description

ELECTRICAL MAINTENANCE TECHNICIAN

Work performed in the Electrical Maintenance Department including electrical installations, maintenance of machines and electrical plant equipment and maintenance and troubleshooting of all types of numerical control equipment.

Duties include: Installing testing, troubleshooting and maintenance of all plant equipment including production machines and testing instruments, new constructions and installation of light and electrical power. Wire and install electrical equipment in accordance with various codes such as National Safety Code, Machine Tool Code and Joint Industrial Conference Standards. Maintain air conditioning controls, battery charging and plating equipment, transformers, capacitors, electronic devices, cranes, elevators, electric trucks, heat treat control instrumentation and associated test equipment, build and install panels, and operation of motor generator sets. Required to perform work in substations and in other places on high voltage (26,000, 4, 160, and 460 volts) equipment. Operate crances in emergencies. Troubleshoot, plan and perform maintenance work on numerical control machines such as positioning errors of all axis, oscillation, drift, collision, tape recorders, tool selectors and tool changers. Use osciloscopes and strip chart recorders to check complicated computer type circuitry, there timing between signals must be within one millionth of a second, electronic counters, pulse rate multipliers, cycle control circuits, integrating type counters, digital discriminators, digital to analog converters and high gain amplifiers. Requires a technical knowledge of electricity and electronics and a working knowledge of tape control procedures. Under direction of supervisor directs the work of lower class men part of the time. Troubleshoot, plan and perform maintenance work on numerical control machines in our plant and/or the customers' plant. Use a variety of electrician tools, measuring and testing instruments such as ammeter, ohmmeter, voltmeter, test generator, Esterline recording wattmeter, power factor indicating instruments, osciloscopes, brush recorder and extra precision test equipment necessary to test all types of tape control equipment.

Use complicated drawings and wiring diagrams and advanced shop mathematics.

Moderate physical effort working regularly with light and average weight materials and tools. At times is required to climb ladders or work in close quarters and difficult work positions.

Somewhat disagreeable working conditions due to exposure to weather conditions when working outside. Exposure to dirt, dust and fumes when working in manufacturing departments. Exposure to flash on job may cause blindness or electric shock may cause death. Exposed to high voltage and high ampere line frequently.

Job Description

MACHINE REPAIR - CLASS A

Works in the Machine Repair Department performing maintenance, repairing and installations of all machinery and plant equipment.

Duties include: diagnose trouble, analyse and interpret drawings, plan and diagnose repair methods. Disassemble, repair assemble, align parts, units and machines. Make sketches of replacement parts, follow up on processing of repair parts. Direct the work of employees of lower classification. Install, maintain and repair service and production equipment and mechanical equipment, including: complete rebuilding and adjusting of mechanical and high pressure hydraulic servo machines, cranes, cleaning equipment, lift trucks, woodworking machines, straightening and arbor presses, sheet metal machines, sand and shot blast equipment, heat treat equipment, elevators, pumps, compressors, photostat machine, blueprint machine and portable tools such as: hand grinder, sander, drill and spray gun. May occasionally use arc and gas welding equipment to perform torch cutting and some simple welding operations. Use a variety of hand tools and operate departmental machine tools such as: lathe, drill press, milling machine, surface grinder and portable hand tools.

Required to use ordinary and/or multi-sheet drawings with many dimensions, sectional views and complex specifications. Mathematics include addition and subtraction of decimals and fractions, trigonometric functions and handbook formulas. Use measuring instruments such as scale, square, surface gauge, level, vernier height gauge, 0.0001 inches indicators, inside and depth micrometers.

Moderate physical efforts working with light and average weight materials and intermittent handling of fairly heavy weight materials.

Somewhat disagreeable working conditions due to exposure to weather conditions when working outside. Exposed to dirt, dust and fumes, when working in manufacturing departments. May get dirty or oily when checking and repairing machines or equipment.

Profiles of Jobs in the Motor Vehicle Industry

From conversations with those in the motor vehicle industry, it was quite evident that, as an industry, they do not plan their production beyond three or four years in advance. None would speculate as to the design of jobs 12 years hence - except to note the continuation of trends today. Perhaps the most revealing characteristic of the future is that they do anticipate producing more models than before. Long-run production schedules for one model will not be as extensive as previously. For the most part, one could conclude that the projected profiles of the principal metal working jobs in the automobile industry do not differ to any great degree from those in the machine tool industry. They are affected by the growing use of numerically controlled machine tools, both in planning, controlling and producing the final product. Here again, the emphasis is on gaining the maximum utilization of a particular machine or machine tool and simplifying the assembly of the car.

It is anticipated that by the middle and late 70's, 81 per cent of the nation's householders in the United States will have one car, and one-third of these will have two or more cars. By 1975, there will be 80 million cars on the road.

During the 60's, the number of cars owned by the nation's families increased at a rate of 3.5 per cent. This rate of growth reflected the formation of households resulting from the post-World War II baby boom, and it is expected to drop to 3 per cent in the mid-70's

Total employment in the motor vehicle industry at the present time numbers 850,000, and by the late 70's, it is expected this total will decrease to 790,000. Seventy-eight per cent of the total workers are involved in actual production (in 1947, this figure was 82 per cent), and 9 per cent of the total employment are females. The number of production workers now employed in the industry equals that of 1947. However, the number of cars produced in 1947 was 4.8 million, compared to 9 million in 1967.

Semi-skilled metal working occupations, such as welders and machine tool operators, account for one-third of the industry's work force, and an additional 23 per cent account for those in commonly considered skilled occupations (Table II). They are machine repairmen, tool and die makers, electricians, etc. White collar employees make up one-fifth of the total work force, and approximately one-half of these are clerical employees. Similar to other major manufacturing industries, the most significant change in years to come will be the increase in professional and technical workers. This will result because of the greater emphasis placed upon research and development, design and engineering activities. As could be expected, programmers and system analysts will also become a larger portion of the work force. Also, similar to trends in other manufacturing industries, the percentage of skilled workers involved in production will decrease because of the greater use of automated equipment. While machinists, tool and die makers, pattern makers, and other skilled occupations involved in production will decrease, there will be an increase in the number of electricians, installation mechanics, maintenance mechanics and machine repair classifications. Insofar as operatives are concerned, some reduction is expected in this classification, although some will replace others as such.

As I have indicated previously, the prospective changes in the job profiles in the metal working occupations in the automobile industry will perhaps not differ in any great degree from those occurring in the machinery industry. We do know this, that individuals classified as machine tool operators, machinists, tool and die makers, tool inspectors, and tool designers will have to know more mathematics and have some knowledge of computer technology. In addition, they will be expected to know some fundamental electronics.

Maintenance personnel, particularly those who are maintaining machine tools of all types, transfer machines, etc., will be required to know more hydraulics, pneumatics, electronics, and other new technologies that are occuring.

Stand-by knowledge of the fundamentals of the trade will not diminish, even though an operation may be automated. Individuals in their monitoring functions will be expected to understand and appraise the operations of machine tools, transfer machines, and other types of machinery. While materials and

Table II

Distribution of Employment in the Motor Vehicle Equipment Manufacturing Industry, by Occupation, 1960 and Projected 1975

Occupation	1960	Projected 1975
Total	100.00	100.00
Professional, technical, kindred	12.20	15.34
Engineers, technical	5.57	7.18
Engineers, aeronautical	2.12	2.13
Engineers, chemical	.07	.08
Engineers, civil	.16	.22
Engineers, electrical	.70	.91
Engineers, industrial	.64	1.13
Engineers, mechanical	1.45	2.05
Engineers, metallurgical	.10	.15
Other engineers, technical	.33	.52
Natural scientists	.47	.51
Chemists	.17	.14
Biological scientists	.01	.01
Geologists, geophysicists	.01	.01
Mathematicians	.14	.22
Physicists	.11	.10
Other natural scientists	.03	.03
Technicians, except medical, dentist	2.86	3.35
Draftsmen	1.18	1.17
Surveyors	.01	.01
Radio operators	.01	.01
Technicians, other	1.67	2.17
Medical, other health workers	.10	.10
Nurses, professional	.07	.06
Physicians and surgeons	.01	.02
Technicians, medical, dental	.01	.01
Teachers	.03	.03
Teachers, other	.03	.03
Social scientists	.09	.10
Economists	.03	.02
Statisticians and actuaries	.06	.07
Other professional, technical and kindred	3.08	4.07
Accountants and auditors	.88	.81
Airplane pilots, navigators	.06	.05
Architects	.02	.03
Workers in arts, entertainment	.48	.50
Designers, except design draftsmen	.20	.29
Editors and reporters	.06	.07
Lawyers and judges	.06	.06
Librarians	.01	.02
Personnel and labour relations workers	.28	.35
Photographers	.07	.05
Professional, technical, kindred, n.e.c.	.95	1.85
Managers, officials, proprietors	3.36	4.19
Creditmen	.02	.03
Officers, pilots, engineers, ship	.02	.03
Purchasing agents	.55	.87
Managers, officials, proprietors, n.e.c.	2.76	3.26

Distribution of Employment in the Motor Vehicle Equipment Manufacturing Industry, by Occupation, 1960 and Projected 1975 (Cont'd)

Occupation	1960	Projected 1975
Clerical and kindred workers	12.88	11.27
Stenos, typists, secretaries	3.28	3.03
Office machine operators	.50	.61
Other clerical, kindred workers	9.10	7.62
Accounting clerks	.40	.37
Bookkeepers, hand	.11	.10
Cashiers	.04	.04
Shipping, receiving clerks	.60	.41
Telephone operators	.13	.09
Clerical and kindred, n.e.c.	7.81	6.61
Sales workers	.65	.70
Craftsmen, foremen and kindred	28.18	26.22
Construction craftsmen	5.67	6.53
Carpenters	1.41	1.48
Brickmasons and tile setters	.04	.05
Electricians	1.79	1.72
Excavating, grading machine operators	.03	.02
Painters and paperhangers	.48	.38
Plasterers	.00	.01
Plumbers and pipefitters	.92	1.44
Roofers and slaters	.01	.01
Structural metalworkers	.97	1.43
Foremen, n.e.c.	4.09	3.98
Metalworking craftsmen except mechanics	10.20	8.46
Machinists and related occupation	4.67	3.50
Blacksmiths, forgemen, hammermen	.15	.11
Boilermakers	.19	.25
Heat treaters, annealers	.19	.15
Millwrights	.40	.42
Molders, metal, except coremakers	.15	.11
Patternmakers, metal, wood	.53	.32
Rollers and roll hands	.03	.02
Sheet metal workers	1.43	1.42
Toolmakers and diemakers	2.46	2.17
Printing trades craftsmen	.06	.07
Compositors, typesetters	.03	.02
Engravers except photoengraver	.01	.01
Photoengravers, lithographers	.01	.01
Pressmen, plate printers	.02	.02
Transportation and public utilities craftsmen	.02	.03
Linemen and servicemen	.01	.02
Locomotive engineers	.01	.01
Mechanics and repairmen	6.06	5.30
Airplane mechanics and repairmen	2.16	1.60
Motor vehicle mechanics	1.69	1.39
Radio and T.V. mechanics	.14	.20
Railroad and car shop mechanics	.03	.04
Other mechanics and repairmen	2.04	2.06
Other craftsmen and kindred	2.07	1.86
Cabinetmakers	.13	.15
Crane, derrick, hoistmen	.36	.34
Glaziers	.02	.03
Inspectors, log and lumber	.00	.01
Inspectors, other	.07	.15
Upholsterers	.16	.11
Craftsmen and kindred, n.e.c.	1.33	1.07

Distribution of Employment in the Motor Vehicle Equipment Manufacturing Industry, by Occupation, 1960 and Projected 1975 (Cont'd)

Occupation	1960	Projected 1975
Operatives and kindred workers	37.36	37.82
Drivers, other transportation & public operator	.93	1.01
Drivers, bus, truck, tractor	.72	.77
Deliverymen and routemen	.16	.17
Brakemen and switchmen, railroad	.01	.02
Power station operators	.02	.03
Sailors and deckhands	.01	.02
Semi-skilled metalworking occupations	22.23	21.37
Furnacemen smeltermen, pourers	.13	.11
Heaters, metal	.04	.04
Welders and flame-cutters	3.73	4.93
Assemblers, metalworking, class A	.98	.90
Assemblers, metalworking, class B	9.56	8.58
Inspectors, metalworking, class B	2.96	2.88
Machine tool operators, class B	4.62	3.70
Electroplaters	.08	.08
Electroplaters, helpers	.14	.14
Semi-skilled textile occupations	.24	.23
Sewers and stitchers, manufacturing	.23	.23
Other operatives and kindred	13.97	15.21
Asbestos, insulation workers	.11	.19
Attendant, auto service, parking	.03	.02
Operatives and kindred, n.e.c.	13.82	15.00
Service workers	2.11	1.82
Protective service workers	.97	.78
Firemen	.06	.08
Guards, watchmen, doorkeepers	.86	.67
Police, other law enforcement officers	.04	.03
Food service workers	.13	.10
Cooks, except private households	.03	.03
Counter and fountain workers	.07	.05
Waiters and waitresses	.03	.02
Other service workers	1.01	.93
Attendants, hospital, other institutions	.01	.00
Charwomen and cleaners	.15	.16
Janitors and sextons	.58	.46
Service workers, n.e.c.	.26	.31
Labourers, except farm and mine	3.28	2.64

Note: Parts may not add to total because of rounding.

metals may change, I do not foresee significant or noteworthy changes in the job profiles of these occupations, other than those that I noted under the section on the machine tool industry.

Conclusion

Speaking directly to the purpose of this seminar - namely, the attempt to gain some insight into the planning of vocational school curricula for metal working occupations in 1980 - I would question whether our conclusions today regarding the prospective job profiles would differ greatly from those we would have made five years ago - or substantially differ from those we would make five years hence.

There is no question that we - both Europe and the United States - are in a period of transition. We both have "old" plants and we both have "new" plants, - plants with the most modern up-to-date machinery. Most changes do not occur overnight; there is a gradual period of transition. Few employers can afford a wholesale transition - of necessity, it is primarily piecemeal. There is sufficient lead time to make adjustments, providing the flexibility is present. While one cannot teach "flexibility", there is the hope that a broad, thorough, basic education is the best foundation for the rapid acquisition of new knowledge and skills. In this regard, we have yet to tap one of our greatest potential educational resources - namely, our factories, our offices, and our laboratories.

When there is recognition upon the part of society that "learning while working" - (not in a casual sense, but a systematic, planned course of study) - is a prerequisite for the success of the rapidly changing technological world we live in, - only then will seminars of this nature become unnecessary.

It has been often said that "a man too old to learn was always too old".

Learning is an individual matter. Opportunity to learn is a collective matter. Our challenge is one of creating the environment with sufficient opportunities and with the appropriate values, rewards, recognition and motivation to prove this axiom correct.

GENERAL EDUCATION NEEDS FOR THE FUTURE

by Bo JONSSON,
Swedish Confederation of
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A functional education of labour

We have not enough information about future human needs even for a date as close as 1980, and it seems reasonable to build future education partly on past experience, but many of our expectations for the future are already reflected in modern educational systems.

We must try to establish an educational system which is flexible and can be adapted to changes in the goals and methods of education. General education, vocational education and adult education must be looked upon as a coherent whole. Education must prepare and stimulate people for changing conditions of daily life in society, in work, and in social and cultural life.

If we approach education from only one of these aspects, that of work, and relate education to the needs of the labour market we might start from two assumptions. Firstly job duties are changing continually so that there is less need for experience and more for education. The rate at which the duties are changing is increasing as the introduction and extension of technical change is speeded up. Secondly, education will consist more of training in finding the sources of knowledge, in understanding, reading, calculating, analysing and solving problems alone or in co-operation with others, and less actual knowledge about facts which soon become obsolete or irrelevant.

The educational system must be one which can respond quickly and effectively to changes, whatever these changes may be: technical changes leading to changing job duties or changes leading to adjustments in the labour force, or adjustments by the individual himself. It must be designed in such a way that it can adapt its programmes to the requirements of industry and the labour market. A current evaluation of the goals, methods and results of education is a necessary part of a flexible educational system; and methods to adapt the educational programme in the light of the findings of the evaluation are also essential. At the same time there should be continuous comparison of work duties on the "shop floor" and job specifications with the requirements included in educational programmes, to ensure that these programmes really reflect the needs of industry.

The limits of technical and managerial development are fixed by the investments in buildings and equipment. It seems necessary to adjust this development of investments as well as that of the education to the needs and possibilities of individuals or manpower. The adjustment of manpower to the requirements of work depends partly on the individual's opportunities for study and partly on increasing the capacity of the educational system. Thus the chance of keeping the balance between labour supply and demand varies on different labour markets with regard both to the investments in new techniques and to the investments in manpower.

The educational system must be able to admit people with different educational backgrounds, and provide each individual with a programme adapted to his own needs and those of the labour market, and must even function in such a way that an imbalance on the labour market is as short-lived as possible.

Education must be looked upon as a continuous process over a great deal of the life-time of the individual. In connection with adult education, especially, there has been talk of individually-tailored programmes which take into account that the learning patterns of individuals may differ considerably.

Educational methods must be adjusted to meet the requirements of those persons who cannot be trained by conventional methods. Research has provided new techniques which can be suited to the individual learning patterns. The quality of education depends not on past standards but on the resources in trained teachers, premises, equipment, methods and programmes adjusted to needs.

Evaluation of the educational system and the methods of education: The educational system and the labour market

The Forecasting Institute of the Bureau of Statistics has studied the problem of analysing the relation between education and the labour market in order to determine the dimensions of the educational system.

According to the Institute this can be approached from two angles, firstly starting with the demand for education and secondly with the demand for labour.

The first approach analyses the reasons for the students' choice of education and occupation: social background, location of educational facilities, parents' education and financial situation, individual expectations from the occupation, earnings, previous studies, etc.

The second approach tries to answer the question of how labour demand will be distributed over trades and education. The economic and social development goals are decisive in this context. The rationalization goals, which imply technical and managerial changes, are included in the national or enterprise-connected goals. This approach must be checked with the first one, as ways of education are interchangeable, choice of education depends partly on the development of the labour market, and the labour market itself adjusts to the existing educational system and the educational structure of the labour force. Production methods and work duties can be rearranged into new job profiles which will be better adjusted to the work force. Special adult education can effect rapid adjustment.

The method used to achieve adjustment depends upon the pressure of demand for education or on the pressure of demand for labour. Methods of evaluating labour market development must also be taken into consideration in this context.

As there must always be some element of uncertainty in any evaluation, the educational system itself must be made more flexible so that the individual does not run the risk of making a completely wrong choice of education. One possible method is to make the education in each field as broad as possible, i.e. containing as much general education as possible, thus increasing the field of work where this education can be used.

What criteria should determine the time for changing the educational system? It is not only necessary to consider whether demand tends to outstrip supply - or the reverse - or whether the balance is being maintained temporarily through changed wage relations or substitutions between different trades, but the socio-economic effects of the latter must be considered separately. It may be desirable to achieve other wage relations or social-occupational mobility and the educational system can be a useful factor in attaining this.

Evaluating the contents and methods of education

The expected changes in techniques and management call for changes not only in the scope but also in the content and methods of the educational system. But the educational goal must not be limited only to adjustment to the requirements of changing work duties.

The type of education needed depends only partly on the labour market situation immediately after the studies are finished. The content of education must be such that the individual can meet other sorts of changes than those within a certain enterprise or branch.

Education is no longer for one profession lasting a lifetime, nor for work in one particular industry, even if there is a variety of jobs in this industry.

General education must be shaped not only in the light of existing or changing vocational training, but must also make the individual capable of adjusting to training in another field of work. It must therefore contain training in finding knowledge, understanding problems and taking decisions jointly and independently. Such general education must not be confined only to the elementary school but must exist at all stages in the educational system.

Vocational training must be designed in such a way that it allows for a late choice of trade and training in closely related subjects so that there is a possibility of changing trades and levels of training. General education must thus play an important role even at secondary school level, though education at this stage is mainly for professions and trades.

For adults who, after a period on the labour market want to return to educational institutions for various reasons, a general education must be available which will take individual needs into account starting at different levels and aiming at different levels.

To achieve all these aims, flexibility in education is necessary. There must be new norms for estimating the studies required so that students can evaluate their future field of work or studies, and also the methods of education for individual students need evaluation especially in further education. Education for working life must also be included.

Where the first year of vocational training is common to various trades, i.e. all trades in the metal industry, it is given in blocks. Later it is specialized according to the different trades, but even during this period a free choice of subjects in closely related trades or other fields is necessary to allow for an adjustment to the labour market or to individual wishes. It would be desirable to have a broad basic education in schools and only a finishing education within firms to enable a person to do a certain job. The school must recruit students from vast areas in order to secure individual choice and variations in education.

General education in view of the consequences for work duties and skills of the technical and managerial development in the metal industry, especially the machine tool and automobile industries.

Naturally all education cannot be viewed in the context of an expected development within a certain field up to a certain date, for instance 1980. The educational system must cater for a continuous flow of young people whose working life may start before and last for many decades after that year; and there are also a number of people already in industry with many decades still to work.

General education given today will have a decisive influence on the young person's possibility of adjusting to the technical structure of the 1980's.

As the skills, work duties and job profiles are dictated by the changing techniques and management of the two industries mentioned above, we can briefly attempt to outline what these changes will be:

1. The processes will be increasingly automated.
2. New metal-forming processes will expand, and older ones decline.
3. New materials will be used.
4. There will be new maintenance methods.
5. There will be an increased combination of mechanics, hydraulics, pneumatics and electronics within firms.

These will probably result in a diminishing number of operators (fewer workers look after more machines), a great increase in the number of skilled people in the field of electronics, electricity, precision-mechanics and servo-mechanics. In addition there will be an increase in the number of persons in planning, management and design. Even in the future there will still be a number of unskilled work duties.

The changes in the work force mentioned above, presuppose an increase in the output of the metal industries. But we can expect both decline, stagnation and increase in the development in different fields and regions. Economic trends, investment trends and changes in the structure of production must be taken into account when we try to relate the development in the industries to the educational system; which means that the educational system may have to be adjusted not only to fill the vacancies, but to the shortcomings in some areas and redundancies in others.

It is in the interests of the metal industry and other industries also to have an educational system which can supply adequately trained new entrants, young or adult, and can assist when transfers on the labour market or within plants are necessary. When recruiting technicians, skilled or unskilled workers, there is an interest not to have the supply limited by fictive social values which can be created in an educational system where the choice of occupation is made early. It therefore seems to be in the interests of both students and industry to have the same general education for all in the elementary school, regardless of the desired future studies, and on the secondary level a general education which will make interchangeability between levels and directions of the studies easier.

In this context it is necessary to recall the hindrances that still exist to the choice of educational levels and occupations. The financial burden of longer studies has limited the choice of education for many people, but this question of finance is much less difficult for young people today. In recent years the geographical distribution of educational facilities has had less influence on the choice, but there are still economic consequences for the adult because of lack of facilities in areas where population is scarce. Finally, the restrictions arising from social and traditional environments still have an effect on the choice of education. The tendency towards theoretical studies is a reflection of the distribution in work and social status between "theoretical and practical" occupations which it will probably take a long time to overcome.

In Sweden, to which the discussion basically refers, 75-80 per cent of the age groups between 16 and 18 will have secondary level education in 1970 as opposed to 15 per cent in 1950. It is estimated that by 1970 there will be 150,000 adults between 21 and 30 whose level of education is not up to that of those leaving secondary school. In the next few decades it seems quite natural to shape the educational system so that it can take in the adults and give them possibilities for longer or shorter periods of general or vocational education primarily to increase individual flexibility on the labour market or within plants but also to increase the potential supply of labour. The work duties in the metal industries will be less in production and more in installation, setting up, controlling and maintaining. The human being will be used to a lesser extent as a substitute for machines. The functions of the machine operator are to understand and supervise the production process, to monitor and to some extent maintain the machine.

Perceptual elements of the operator's job will become more important than sensory-motor processes. It is still uncertain what individual qualifications will be the adequate ones in each case, but a capacity to combine and foresee as well as other "mental skills" will be considered. Knowledge will be more important than skill.

What has been said earlier about education seems to be relevant in this context. New material might render trade differences obsolete, for example, if a factory changes from sheet steel to plastic it will have to retrain its labour force, which can be replaced only to some extent.

Changing techniques will to some extent eliminate the need for loaders, handlers and joiners. The changing techniques of metal forming will result in a decline in the trade of fitting. New material will affect trades such as plumbing and pipe fitting and will require less manual skills in their utilization. Even if traditional techniques remain, especially in smaller firms, these will decrease in number because of increased labour costs.

To keep up the technical efficiency of a complex and delicate automatic system in the entire factory, maintenance work will increase. It will require a combination of electronics and mechanics, pneumatics and hydraulics. It must be carefully planned. To reduce down-time, machines and methods will be developed to provide replacement of items which, instead of being repaired on the spot, can be dealt with in centralized workshops. Part of the maintenance work will therefore become less qualified but will need more diagnostic skills.

It is obvious that more analyses will have to be made of work duties in co-operation between labour and management. Even if it is generally accepted that work duties will need more perception, selectivity, precision and foresight, they must nevertheless be carefully surveyed. Vocational education in the metal industry requires a certain general education to enable people to learn the techniques, material, methods, processes, diagnostic skills, etc., and to establish a learning technique which will be useful when new knowledge or skill is required. There is an increasing demand for skill and knowledge in various fields more or less connected with one another.

Workers will more and more have to carry out work in co-operation with one another and the isolation at work will require an education which trains people in methods of co-operation and in taking decisions independently.

Skill and knowledge requirements are based upon the expected work duties but they must clearly be adjusted to the job profiles, i.e. various combinations of the work duties. Job profiles may well become more variable in the future. As the educational gap between an older and a younger generation will tend to become greater in the near future, the job profiles must be adjusted to the possible training of, for instance, an older worker in order to achieve better individual job satisfaction and average income development.

To be able to meet these claims, more co-operation between labour, management and schools is necessary. The greater the flexibility in the educational system the less will be the need for long-range forecasts of changes in work duties in small and limited fields of work. The more flexible the education, the less the pressure on the individual who is adjusting to new jobs.

GENERAL EDUCATION FOR THE PREPARATION FOR WORK LIFE

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As it becomes increasingly clear that all people, whatever their station in life, have a part to play in the economic life of their country, a marked change is being made in our educational system. Distinctions between the training for the academic and the non-academic are disappearing. At the same time increasing democracy in political life makes it necessary for all citizens to be able to understand the public issues affecting them. The pleasures of leisure time activities are no longer the special province of the elite. Members of all social groups want to enjoy them.

These three streams of educational activities are no longer considered distinct and separate, as their historical antecedents would suggest. Together they can help to prepare man for a richer personal, civic and vocational life which would be more satisfying to the individual, more productive for the economy, and most helpful to the nation. The streams of education are merging; the individual's goals are becoming more similar.

Where differences exist, they are not so much in the actual areas of interest but in the amount of time and intensity of interest devoted to each of them.

These changes are also specifically reflected in the preparation for work life. Narrow specialization in education and training, old-fashioned apprenticeships and specific job training are no longer adequate for survival in the labour market. At best they can help an individual gain his initial job but they will not carry him fully along his work career. They may even implant a false sense of security in an ever-changing industrial world. After this type of training individuals may find themselves ill prepared for the new demands in the labour market. There has, therefore, been a strong reaction against excessively specialized training. The trend is towards a broader type of education which will enable a man to adapt to the complicated urban society continuously altered by new technologies and sophisticated industrial systems in which he may be in charge of vast and costly equipment and his aspirations will continually increase.

Preparation for work life is therefore being built on an enlarged base of general education. The justification for this broad view of future requirements has already been shown in other papers. We are only certain that the automobile was a creation of this century and will be supplemented in this time by newer systems of transport. What they will be we are not certain. We ask ourselves many far-reaching questions. Will we be propelled through space on the earth's surface, the air or underground? Or will we substitute the communication of images, signals and information for actual personal spacial relocation? What type of cars will we be using? Will they be made of plastic, or metal, aluminum or steel? What type of motor will they have? Will it be petroleum or electric battery driven? Will it be personally or automatically guided on the roads? The projections will differ; not all can be right; and all may be proved wrong. But children entering school in 1968 have to be prepared as best we can for jobs in the 1980's. To educate and train for today's job patterns would sacrifice them at the altar of our inertia.

Similarly as respects the machine tool industry, we can only be certain that some metal or material shaping and forming will continue. But how much and by what means it will be done is less clear. The original blocks of materials may well have been trimmed to size before the forming and shaping occurs so as to reduce later processing to a minimum. Will the numerically controlled traditional machines be able to withstand the invasion of electronic machinery and the many other new technical alternatives now competing with the older methods? Economic and technical forces will determine the outcome. But the safe prediction is that the technologies of material forming will be changed and with these shifts will come basic alterations in the machine tool industry as to its technology, size, and jobs.

Educational Demands of an Urban Society

The previous papers have impressed us with the rate and far-reaching nature of the impending changes in the technology, structure, and methods of organisation and systems of management in the metal industries. People must be prepared for them. But these new innovations and those in other areas will also have profound effects on the physical nature and the technology of our society. The community of today is of course vastly different from that of the past and the future will be even more profoundly altered.

The ability to deal with these changes is as vital a part of the programme of job preparation as the learning of manipulative skills. It is a necessary preliminary to effective occupational education. To participate independently and responsibly in the community calls for the mastery of considerably advanced knowledge and tools of communication. The further acquisition of the occupational knowledge and skills is in a sense an elaboration of the competencies needed to live in this environment. A measure of their indispensability and the high cost of their absence is provided by the problems encountered and the disturbances often caused by rural and foreign populations who come to new urban sites. The so-called impersonality of the large urban community in fact reflects the shift of much of the responsibility for choices, and adjustment to the new environment and society, to the individual himself. He must be able to navigate within the community and must also be motivated and capable of advancing within it. The educational system must help to provide him with these skills and knowledge.

Besides having to deal with the complicated social and civic organisation, running a home demands an ability to deal with a variety of advanced technical products. The sobriquet of "household engineer" assigned to the housewife is not in fact an excessive claim for the varied knowledge we expect her to possess for the operation of the modern home.

In addition, the individual citizen should be able to understand the principal controversies arising in the community and be able to exercise his choices most deliberately. Fortunately, education helps to increase the capacity for making calculated decisions and the schools have a particular responsibility for heightening the capacity in co-operation with the other agencies of communication.

Educational Demands for the New Industrial Setting

In defining the educational system required, the demands for education and training for participants in our industrial society are of vital importance. The characteristics of these demands can already be discerned, though of course many major innovations can be anticipated in this area. The most evident shift will be the acceleration of the very rate of innovation and its penetration of the industrial fabric. This may be either major or minor, but in either case the effects will be radical. The final result will be a high rate of job turnover. Man can expect changing jobs, employers, and industrial attachments and often shifts in location. Even when they are not radical, they will be continuing and demand adaptation. Older industries will be transformed and wane and newer ones will grow into formidable sectors in the total economy. While the manpower demands of the growth sectors will in some cases be met by the new entrants into the labour market, many of the employees of these industries will still move into them from existing employments. Rights in jobs will not be preserved but the right to a job can be assured by our economic and political authorities.

It is commonplace to talk of the effect of mechanization and the growing importance of automated processes and controls. They are evident everywhere. Research is producing new materials, processes, and products. Synthetic materials are replacing natural ones or adding to our range of choice. Evidence of these developments has already been noted in the two industries with which we are concerned.

But what is important for our purpose is the impact on the demands made of employees. Manipulative skills are losing their central significance. They are being communicated to machines or tapes or are disappearing. In their place the cognitive and perceptual skills are growing in importance. Knowledge, recognition, judgement, warnings, and action have become important. The craftsman, who gave way to the machine operator and the assembly hand, is now being superseded by the white overall machine minder. The abilities which earn him his place in the enterprise are those of the capacity to anticipate, diagnose difficulties and respond to them. The accent on productive output is being replaced by an emphasis on continued machine operation which will in itself assure higher output. Physical exertion and manual skills are growing less important and alertness and responsiveness are the key qualities. They are sought among employees of the lowest and highest rungs in the enterprise. They are differently applied, require varying levels of knowledge and training, and involve a wide range of levels of responsibility but they are increasingly similar in nature. The skills of communication and response to instructions and information are critically important in our industrial society.

The above trends do not eliminate the older types of employments, but they do reduce their relative importance. And even they are changing in character. The craftsman must learn to understand new materials, processes, and systems. He has more complicated situations to tackle.

Organisational structures are becoming more flexible under the impact of higher capital investment, more automated equipment, and the rising complexity of our problems. They are less rigid and allow for more local decision-making despite the concentration of authority in many fields facilitated by improved data processing techniques. Moreover, more use is also being made of outside contractors and consultants to supplement the internal resources of the enterprises. Organised and regularized use of research and development are supplementing, if not supplanting, haphazard and intermittent spurts at innovation. The increased training of management in advanced quantitative techniques for decision-making has also raised the standard of sophistication required of most levels in the enterprise.

Along with these changes in the industrial environment, we may note that enterprises are growing larger and their structures are becoming more complex. Their geographical scope is being extended to span continents and the world. Bureaucracies are being built for standardizing policy and practice while the range for local discretion is being increased.

The effect of these changes on the jobs in the modern enterprise is most revolutionary. The responsibility of employees in all rungs is being extended. They supervise more expensive and more critical equipment, processes, and stations. This expansion is of course reversible and subject to readaptation. Older job patterns as well as more extended levels of hierarchy can be re-established. But the confluence of forces is in the direction of compressing the hierarchical structures and in transferring responsibilities to the lower echelons. As a result, the latters' jobs are becoming more important and possibly more engaging. This frees the high levels within the enterprise of their former routine duties and they now take on newer functions of co-ordination and testing and monitoring and adaptation. The image of the old working boss is receding in modern industry before the new profiles of machine minder, technician, and the professional. International competition and corporations add much pressure toward universalizing these trends.

Implications for General Education

The above trends and demands made on people as citizens and participants in the industrial system have increased the accent on the broad preparation of all people rather than on training for specific, often transient, skills. The latter should be acquired after having received an adequate education rather than in lieu thereof. It is for this reason that the main focus of interest is upon the secondary school, for it is here that the major transformation is being effected; the traditional patterns are being found obsolete and newer ones are being shaped.

While the above accent is upon the need for upgrading the general educational background for the great mass of people who had hitherto received only elementary education and direct vocational training, parallel revisions are being made in the preparation of people for the technical and professional ranks. Theoretical knowledge is no longer adequate for them. Their occupational and civic and personal lives demand greater understanding of the common materials, processes and systems of our industrial society. They should acquire and be familiar with a variety of manipulative skills. They too must be prepared through a combination of general and manual education.

What are the common attributes of the educational process needed in the years ahead? It must inculcate firstly willingness to learn, a capacity to benefit from experience, and a disposition to continue the learning process through one's entire life. Education cannot be a terminal process. These goals demand a wholesale review of teaching methods, curriculum and school organisation, for the existing ones do not produce the above results. They have failed with many students. The school systems have still to orient themselves to these tasks. But there is a broad acceptance of the importance of these objectives if we are to prepare our people for adaptation and survival in our modern world.

Second, there must be receptivity to change. It has been growing as the rate of innovation and its penetration have increased and the benefits are widely shared. But many points of resistance and doubts still arise. True enough, programmes for facilitating change and assuring positive experiences are essential to building up favourable attitudes among the mass of people. But it is necessary to educate the people to be able to examine the obstructions and the nature of specific changes, so as to anticipate the methods of overcoming the negative effects and finally to bargain for the appropriate series of adjustments and to define their demands for benefits. They will then be able to take the risks in their stride and co-operate both in their innovation and in the adjustment process.

Third, the methods of teaching must be better adapted to man's learning capacities. Instead of being school- or subject-oriented, the methods must be pupil-oriented. The didactic verbal methods of the past possibly suited a student body consisting of the elite whose future did not demand their active professional participation in the society. Knowledge of doctrine and the cultivation of the arts of sophistry may well have served prior centuries, but they are no longer adequate. The learning population has multiplied. Educational preparation is now required for many different types of occupations. The aim is to develop the personal capacities to become better problem solvers. The challenges of the modern economy and society rely not only on intellectual but also on creative, social, manipulative and other skills and the educational process must cultivate them.

The need to prepare people of different ages, sexes, backgrounds, capacities, and growth proclivities who are at different stages of development demands great flexibility in methods. The new experiences with people in developing countries have reinforced the lessons being learned in our own societies. The difficulties of incorporating the children of the underprivileged into the mainstream of the educational flow have called for new approaches. The recognition that indoctrination and training in specific knowledge must give way to the development of an ability to deal with a limitless expansion of new understanding demands novel approaches to teaching. In dealing with the teaching and training of adults, the teachers have found that the traditional techniques no longer suffice.

The common thread running through these findings is that instruction has to give way to an active process of learning. Many people among the young and particularly among the adult and older persons learn best and most easily when their education proceeds from experience and experiment to generalization and is then modified through the further experience of application. Abstract findings should be supported and corrected by clinical experience. It is not enough to take up the slogan of learning by doing. Investigative learning is the method which more adequately serves the needs of our day. Where it is applied to training for specific manual experience, it has been referred to as "the discovery method". It is most useful for persons of lower intellectual potential who have difficulty in learning by the traditional teaching methods. Essentially its emphasis is upon adaptation to individual needs and personal learning speeds. It builds upon the acquisition of some manipulative skills and helps to develop the powers for conceptualization among all learners.

Fourth, the education process and institutions must allow for great flexibility and mobility from one area to another. There cannot be rigid categories. Students must be able to shift from one to another without excessive penalties as their talents and interests unfold. It is particularly important that persons who have the necessary intellectual capacity should be encouraged and helped to continue their education in the formal schooling systems. This approach of course reinforces the need for a broad basis of common subject matter for a prolonged period.

Fifth, the schooling period has also to be long enough for this general educational process to be effective. The age for occupational commitments must be delayed. In fact this principle is now being widely recognized as compulsory education is being extended. Fourteen is commonly the dividing line before differentiation is started and vocational education is initiated. Moreover, the emphasis is on general education during the early years of this vocational educational and training period. The emphasis is upon the general education rather than upon continuing the older emphasis on specific manipulative skills. Educators have long observed and have been adapting themselves to the fact that few students actually use the specific knowledge acquired in vocational training and many move to newer occupations and opportunities.

Subject Matter of the General Education

The changes in methods and approaches to education are of course reinforced by re-evaluation of the subject matter to be included in the curriculum for general education. If it is to be useful to the general citizen and for all rungs of society, it must obviously be different from that needed for the academics remote from society itself. The preparation is not for the detached but for the men who are participating actively in society, for the citizenry which is to be encouraged to move up the economic and social ladder and to take advantage of the opportunities as they arise. The education must be such as to prepare for participation in society, for occupational activity and for a full personal life. In this review of content, the emphasis is focused primarily upon the second field. The conclusions and judgements must obviously be reconciled with the other two.

First, the subject matter must include the development of the skills of communication both oral and written and the computational skills. Without mastery of these, participation is necessarily deficient.

Second is a knowledge of our economic, political and social institutions and organisations. Insofar as possible, these courses should seek to introduce the student and have him deal with the real problems, however much they may have to be simplified for his understanding. In each of these areas the particular society has worked out a temporary answer which is only partially effective and which is undergoing changes. The underlying challenges remain the same. It is these persistent problems of social organisation which the student must understand. In addition he should be carefully tutored in the ways in which the present society has organised itself. This learning also entails formal introduction into the work society through visits from and to it.

Third, the occupational life involves the knowledge of materials, processes, systems, devices and skills. They are in fact the material expression of the fundamental findings of science, the operation of our physical world. We have urged that all students should have a common basis of learning in this field, whatever their ultimate professional interests may be. The educational system should introduce the student to them and give them an opportunity to experiment and experience the variety of alternatives in this field. The laboratory and workshop must be a classroom for part of the learning period for all of these students. This emphasis does not require dedication to a specific manipulative or occupational field, but it does call for an introduction and an elementary experience with a number of them. Fourth, the school system must also cultivate good health and knowledge of human behaviour so that the student is able to understand himself and his fellow men and thus becomes a healthier person.

Conclusion

A general system of education should cultivate the fullest range of personal qualities of the student body whether they finally end up as manual workers, white collar employees, technicians or professionals. People generally in our society are likely to take an active part in our work world. Occupational preparation is required by and must be provided for all. In a changing technical world and with the extension of the principle of opportunities for education to all sectors, the educational process has to prepare all for the three-fold existence as a political citizen and a private individual and as a productive member of the work world. These common needs demand a common educational system. As sophistication has grown, the period of general education has been extended and it will be further increased. The base has broadened so that there is room for the widest preparation and facility for adaptation.

Preparation for the automobile and machine tool industries cannot be different from that for other industries in the area of general education. The differentiation can only follow when vocational commitments are made and they must be delayed. The emphasis must be on preparation and adaptability to change, which means above all else that specialization is postponed and vocational education must also be as broad as possible for as long as possible. The soundness of these principles is being more widely accepted both as they apply to simple manual occupations and professions. Vocational education and training should cap a prolonged period of general education rather than be a substitute for it.

GENERAL EDUCATION NEEDS FOR THE FUTURE

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This is the title on which I have been asked to contribute a paper. I have been warned that I should try to keep my observations to the "Work life preparation for 1980". But I must protest a little that the work life is only a part of the whole life and it is the whole life with which the educationalist is concerned and for which a general education must have regard. I also believe that many of the industrial dislocations with which we have been beset have sprung from employers failures to see "work life" as only a part of real life and for employees to see that it is a real part of any life. The increasing interest which employers show in the general welfare services of their employees, the increasing provision of facilities for recreation and welfare and the very considerable efforts made to achieve personal integration of employees within their society, is perhaps some excuse for the educationalist in this Seminar to lift his head a little from the workshop floor and sniff the air which the worker must get into his lungs if he is really to live. I shall console myself, and I hope others attending the Seminar, with the knowledge that the great majority of papers, and indeed all other sections of this Seminar, are sharply focussed on the Metal Worker in 1980. In this paper I shall exploit a larger canvas which I hope may be seen, in the long run, to have some relevance. I shall be concerned with the general education of the sort of persons who may by design or chance find their way into the metal industry by 1980.

Environmental Education

I can only comment as an educationalist, and as an educationalist schooled in the English tradition with all too little contact with education abroad. We English are a little suspicious of foreign ideologies. For generations we have, in vacations, travelled to our frontiers taking our picnic baskets with us, and taken off our clothes and sat in the sea. To go further than this has seemed perhaps frivolous and when we have ventured we have generally expected those in other lands to speak our language and accept our ways. In this way, we English, have encouraged a built-in conceit which Europeans must find a little naive. It must then be part of our general education for the future, in a world wide situation, to recognize and remedy this. Indeed I put this forward as a concrete suggestion that those eight-year olds now in our schools who will be employed in 1980 should in their history, their geography, their language studies, and their economics be brought face to face with an environment significantly larger than the parish in which they are born. There is an immediate and overdue need for curricula reform if we are to provide our children with the general education appropriate to the demands of 1980. It is essential that our children realize something of the new world environment in which they are required to live and are brought to some understanding of the economic facts of life. During the past year we have seen our educated democratic society bewildered by the mysteries of high finance. Against a background of ignorance, suspicion grows and confidence flags. The metal worker of 1968 is not disposed to put his heart and soul into his task if he has a deep-rooted suspicion that gnomes in Zurich can make his earnings buy less and impair his basic currency. This is not to suppose that children in school will be able to master the intricacies of economics, nor should they be encouraged to lose themselves in the jargon economists produce; rather should they be trained to judge, on first principles, policies advocated and defended. It is surely a mark of defective education that at a time when it was obvious that we had to establish world community some of our schools of economics were allowed to continue to advocate a favourable balance of trade as the only way of securing stability. Such a policy, pursued by all nations, is patently absurd. The unfavourable balance cannot like an astronaut be rocketed to the moon, it is dissolved in the international conflicts and wars which some economists, in consequence, almost seek to justify as a means of avoiding unemployment. We must not expect adolescents to be unaffected by their sub-conscious appreciation that this sort of inherent nationalism is increasingly disastrous. It is, however, our task to offer them better solace than drugs and disc jockeys.

It is necessary to see this development as part of a continuing evolutionary process which may require acceleration and direction. We are inclined in England to avoid the disruptions of new thinking by a modest admission that old thinking is not without merit. Education today is over-fenced by school and traditions. There is a dangerous confusion of education and schooling. It was a fellow Shropshireman who demonstrated with compelling clarity that the human animal has evolved from a more primitive form under the challenge of a strongly educative but natural environment in which the unnatural contribution of schools and pedagogues played no part. It required no Director or Department of Education to bring man down from the trees and stand him upright on his two feet so that his hands could the better be employed in making things. And this perhaps is a good thing, for in this generation we might well have lingered in the branches waiting the arrival of a ladder or escalator. We need to examine the general education we provide in terms not merely of erudition but in its stimulation of initiative and in the knowledge that more remote environments impact upon us with unprecedented speed.

There is no reason to suppose that the out of school environment which we provide, or which we allow to be provided, for our children is less influential today than was the natural environment in the days of our primitive ancestors. This confusion of schooling with education is a serious error. Teachers recognize, indeed are forced to recognize, that they are only one factor in their pupils' education. Children learn as quickly and as easily from their contemporaries as from their tutors. They are educated most effectively when they are involved in enterprises which they feel to have relevance to the real world in which they live. The town child can cope with traffic better than his country cousin, but he will detect the bird's nest less readily.

The emphasis today is more on learning than on teaching and environments in which purposeful learning is facilitated. Our schools are becoming richer in the opportunities they offer but there is still need to recognize that for the average child the life size is more meaningful than the model. He is attracted to the boat in which he can sail rather than the model which demonstrates the principles of sailing.

Home Based Education

It should be noted that life-size education neither begins nor ends in the school. It has been said with truth that it begins in the womb and ends in the tomb. It belongs to a 24 hour day and a 365 day year. Only schooling comes in terms. The young worker of 1980 will have been as much influenced by the education given in his home in his street or club as anywhere else. He gathers up more than dialect from his parish. If we are looking to the children who will come into work further in the future than 1980, we can see at once the need for the education of parents now and a reappraisal of the importance of the early years of a child's life. It is a characteristic of our technocratic age that we over-estimate the importance of things that can be measured and under-estimate the importance of things less capable of measurement. So in England we have set up our ante-natal and post-natal clinics to weigh and measure and correctly feed the bodies of our infants. Never in history have we had such magnificent infants' bodies. But as to what goes on in those bodies, the mental development, the attitudes and complexes, we are strangely indifferent. We have assumed without reason that parenthood implies teacher status. In the affluent society we find the child frustrated by the broken expensive fragile toys which he has been given, when a stick and a tin-can would have served him better had his parents known what his real needs were.

We need to begin at the beginning with our education, and indeed with our schools. We have yet to realize in England that Primary Education is of primary importance. The primary school teacher has an important diagnostic function as professionally demanding as any technical instruction which may follow. There is as much frustration built into our children by inadequate diagnosis before eleven as ever results from imperfect selection at eleven. And if we are to meet the needs of young workers we have to be satisfied that they and their teachers have properly assessed their capacity and interests. This can only be done if there is close contact between home and school. This relationship has been recently stressed in both the Plowden and Gittins Reports. This relationship between home and school in England has tended to change in the past decades. With increasing emphasis on examinations and certificates parents tend to be encouraged to regard schools as some sort of processing factory into which the raw material of ignorant children is poured and transmuted into well-qualified certificated potentiality. The whole process is thought to be capable of achievement without effort and without pain. My parents' enquiries at school were more directed to my character than my capacity and a ready rapport between parent and teacher did not encourage any complaint on my part regarding the painful or pleasant techniques which the school employed in the educative process. Today the enquiry is more often addressed to the prospect of examination results and the transfer of responsibility for success to the teacher, the school or the director of education. It is not always easy to convince parents of the significance of heredity. The welfare and egalitarian concepts which, quite properly, have developed in this century have not yet fully resolved these issues. The ration mentality which sprang up in the war years has subconsciously produced a quantitative rather than a qualitative approach to our problems. We are at times a little unwilling to recognize this quantitative element in democracy. None the less with peculiar perceptiveness while we leave the body politic to the voter enfranchised by age alone, we are careful to trust the body anatomical only into the hands of the trained and educated physician.

Academic Traditions

I have already referred to the conservatism which is almost inbred in our education system, which in schools has produced a climate of appraisal in which the academic acquires laurels he scarcely merits and the practical pupil is derided for his academic inadequacies. Our schools are slowly emerging from this long and abortive tradition as technical education acquires reputable accommodation in place of the old disused schools of fifty years ago; and as industry is prepared to offer prototypes of apparatus and equipment rather than broken down items of obsolescence. This change could be accelerated if we were to address ourselves with determination to a new look at the way in which our school teachers are trained and our schools built and organised. It is surely a remarkable thing that the great majority of our children, including the potential metal workers are for most, if not all, of their school life taught and trained by teachers with no first hand knowledge of the life the children will lead either in work or out of it. The dichotomy of education and training which is built into our Industrial Training Act reflects more of the boundary disputes of empires than the unity of experience which is the essence of the educative process. When to this is added the subtle dichotomy of varied reimbursement, confusion is worse confounded. So I would say that those who will be in the metal industry of 1980 will need, almost at once, a new more realistic and relevant, secondary education than we at present provide. This is not to suggest that his general education will require training in precise skills, but rather that he be made aware of the world in which these skills are relevant, that he be encouraged in his history, his geography, his literature and his art, to recognize the dimensions of the twentieth century. In such dimensions, and with the limited time he has available for the acquisition of knowledge, it is necessary to ask with candour what does he need to know, too often he is taught what his teacher had to learn. Such a desirable situation will not be achieved unless we take steps to broaden our recruitment of teachers, open our schools to the controlled impact of the outside world and return our teachers to the process of in-service training and retraining. The flexibility which is thus invited into our schools must be similarly built into the attitudes of our pupils.

The story of evolution is the story of flexibility. The dessication of Devonian times placed a life-saving premium on creatures which could survive on land as well as in the sea. So was born the generation of amphibians. The lesson of history can be focussed on man's survival by adaptation. This is the new thinking that will bring our youngsters into society more concerned with development than demarcation disputes. It may be doubted if this flexibility can easily be produced in a school too rigidly structured in moduled classrooms, too strictly functioning in fifty minute intervals of instruction, too statically based in desks, or over-conditioned by examinations, whose methods of appraisal are rendered objective only by restricting the technique of enquiry to what can be objectively measured. Techniques of continuous appraisal are being and need to be developed. It seems to me that these must play an increasingly important role as the traditional certificates of general education potential become more suspect and less adequate to modern requirements. We have tended to place a wrong valuation upon our certificates, regarding them more as cheques to be cashed than tickets entitling the holder to travel. It may well be that effective educational advance will necessitate a revision of their period of validity so that a periodic renewal will indicate the need for refresher courses and encourage the flexibility which is necessary in a world in which change is a major characteristic.

Educational Reforms in the Home Environment

Attention has already been called to the need for training parents in the educational requirements of their children. This becomes increasingly important as it is clear that the less able tend to have larger families and the illiterates demonstrate their virility. This is obviously a greater problem in some areas than others but by 1980 we shall have need, even greater than now, to realize the impact of world wide conditions. This need for parental training is not just a matter of instruction in infant welfare. Today parents find as much, if not more, difficulty in their relations with their teenage children than with their babes in arms, although it is important to realize that an imperfect start predisposes an imperfect development. Our education, in the past decades, has fallen rather heavily into the hands of psychologists and theoreticians. "The child" about whom I learned so much from my professors has so far mysteriously avoided any direct encounter with me. And it is a solemn thought that as a result of our scientific progress we have emptied our hospitals of consumptives and filled them with neurotics. An early appointment to the staffs of new universities is the psychologist or psychiatrist, allegedly to deal with first generation students but perhaps no less necessary to help first generation staff.

If we begin in the home to which the metal worker may for a year or two return and in which from now until 1980 he will probably exist, it is important to identify needs. Most homes have now succumbed to the mass media and have hoisted their sign of surrender from their chimney stacks, without distinction of class or creed. The council house, the slum, the palace are all tuned in. And having, in the war years, learned to use "points" whether needed or not, there is a great temptation not to miss anything that might be on. It is quite surprising that it is now almost the rule to keep the pop and the "telly" on even when visitors arrive, or whether or not anyone is really involved. We have created a noisy environment and if we are all jiggling like puppets it is not to be wondered at. From the noisy fast moving outside world the youngster comes as spectator into the noisy inside T.V. world. He is learning fast how to stay up late and get up later. We are exposed outside and inside to the seductive pressures of advertisement. Even the announcers of forthcoming events can no longer present their wares without the gloss of salesmanship and the build-up of careful conditioning. In contrast to this salesmanship, which aims at canvassing viewers in the competitive world, the news is thrust forward with universal depression. A thousand buses pass each other in safety - a million people travel by air unhurt, but we are not encouraged by this achievement for it is hardly mentioned. The two buses that collide - the one aircraft that falls - this is news. Small wonder if our neurosis grows or if in self-defence we assume a callous indifference. The family unit, participating in a sing-song round the out of tune piano had at least an element of involvement and individuality, which united the household. Our preference for an insistance upon particular programmes now has the opposite effect. The modern home with all its amenities is not necessarily a better educative environment. And while no one advocates excessive adversity, the long history of evolution has not failed to find in adversity a spring-board to advance.

A child in the home needs intelligent security and developing freedom, a consistent and meaningful discipline - all these contribute substantially to his subsequent development and attitude to whatever job he seeks to do. Not least significant is the example his parents set. The relationship between mother and father is as important as providing children with the basis on which they can apply themselves to their work and study as is their native intelligence. It is significant that in England we spend infinitely more on providing facilities for married people to separate than we do in providing training for them to live together. And in our approach to marriage and the establishment of the home even our well meaning advisory and counselling services seem to have abandoned the conception of love which involves sacrifice for a preoccupation with the lesser concept of love which involves little more than sexual intercourse. We cannot write off the consequences of accepting without question a purely secular society. A sixth form student recently told me that he had been surprised in talking to his grandparents that they seemed to have experience of a type of love of which he had heard nothing on the radio and of which he had found no record in modern writings. This appraisal of human nature which is inherent in the current permissive philosophies is more relevant to the general education of the young workers than we are at times prepared to believe. We do not establish the sense of basic security and purpose from which maximum effort derives if we can tell our youngsters that they are not lost only because in reality they are not going anywhere. Our general education is required to give meaning to life if from our metal workers or from any other group we are to achieve the output which our needs require.

I would suggest, therefore, that our parents need to be helped to get these matters in focus right from the start. Right priorities need to be established so that at every stage the growing boy knows that he is not alone although he is increasingly free. This is difficult to achieve. More difficult, for instance than driving a car. It is strange commentary on our sense of values that we accept that we have to be tested before we may drive, and that now we must by law avoid incompatibility even between our tyres lest we skid on the highway. How much more important are human incompatibilities. Much needs to be done even in the physical environment in which our children grow up in the home. Family houses are still ill-designed to meet family needs. We have, it is true, got past the stage when we only put bathrooms in the homes of those who never got dirty, but we are still unsuccessful in designing our dwellings so that the varying needs of varying age groups can be met. We are beginning to build nursery schools into our blocks of flats and in some countries attempts have been made to provide, as it were, a community home; the kibbutzim of Israel come to mind, but more thinking and planning is needed in the establishment of suitable home bases for our teenage children. I am not impressed with the potentials of the moduled tower flats that are now almost the worldwide offering for this basic need, even when they include a youth centre round the corner to provide recreation rather like the culture which is heaved into technical colleges through the windows of liberal studies and two extra periods in the timetable.

From the point of view of general education of the young worker in the next decade I am, therefore, suggesting that more should be done by way of educational reform to involve parents more effectively in this education from the start. At the same time more needs to be done to ensure that the new environment of their homes (increasingly these days to be found in skyscraper blocks which appear to have so many amenities), has within it not only an alcove for the **pram** but enough space and provision to offer an educative environment which evokes from the growing child a maximum response. They will achieve something if by 'labour saving devices' they allow both parents to give to their children the time and personal attention which growing children require and often, when both parents are employed, fail to secure.

It is generally agreed that despite a certain element of precociousness we have in our children a progressively earlier maturation. It has been demonstrated that educational development is accelerated when children are in company with others. Pre-school play groups and nursery schools properly equipped and professionally staffed can, therefore, make a substantial contribution to the general education of children. With the expanding frontiers of knowledge and the growing complexity of living, and without wishing to accept the compulsions of the current "rat race", it would seem that we have at the present a special responsibility not to waste the early years of a child's life. A lowering of the school entry age may be as important as a raising of the school leaving age if we are to prepare our children for the 1980's. This will not occur, however, because we are not as yet seized of the importance of these pre-school years.

Educational Reforms in the School Environment

A technocratic age demands a better appreciation of mathematics and the skills of measurement and calculation. As we move inevitably into the age of the computer the tedium of calculations may be improved and the labour attached to them reduced. It is, however, important that the average citizen should have some understanding of these techniques so that ignorance does not produce the same frustrations to which reference has already been made in connection with world finance.

It would be unfortunate if mankind escaped from the worship of an irrational deity only to bow down before an incomprehensible device.

It is not suggested that the average worker will become a master of computer techniques but his schooling in mathematics will enable him to hold them in proper - rather than irrational-respect. Mathematics has often been a mystery, especially to girls. It is increasingly recognized that this is in no small way the consequence of inadequate teaching. We have fragmented and traditionalised our approach so that the child never saw that (a + b)(a + b) was only another way of expressing the geometrical square, itself composed of two squares and two rectangles. We are now in schools trying to attach objective reality to our mathematical symbolism. It is no less encouraging in England that we have resolved to move into the more sensible procedure of decimalisation and metrication. Only the conservatism of our race has seen this as requiring two stages. When new decimal currency is introduced in our country, educationalists will hope that we shall not lack the courage to use the real medium in schools rather than the cardboard facsimiles. It is a good plan to have reality, even if it does mean a careful checking of the bank and a more painstaking cultivation of honesty.

A development which is to be welcomed in England but which is already traditional in other countries, is our changing attitude to a second language. No deficiency is more widespread among the English than our inability to talk except in our own tongue. If a second language is to be an effective means of communication there is obvious merit in introducing it at a time when children are most communicative, and of introducing it in a natural rather than an academic manner. We have tended to regard the second language as the distinctive mark of a secondary academic course, and we have traditionally begun by the most sophisticated exercise which is translation, and at the age of increasing introspection. We are coming to realize that it belongs to the extrovert years of eight to twelve. We have underestimated the capacity of the average child to acquire a second language if placed in an environment where there is every incentive for it to be learned. The acquisition of a second language does more than provide a second line of communication, it provides, as it were, a second base point from which the better to survey the human situation. This is necessary if we are to avoid the insularity of our English tradition. The young workers of the 1980's should have within their general education every incentive to move across international frontiers, reducing in practical terms the national prejudices we can no longer afford and which still tend to erect walls and barriers across the territory of a world where survival depends upon effective unification. It is a significant comment on our academic approach to language that in a recent local survey not more than 5 per cent of persons with A level French had within a period of six months tuned in to the French news!

The same need for enlarged horizons must be met by an increasing willingness to review our history teaching and, having regard to the limited time available, decide what can properly be included. In general English children are ill-informed on our own history and almost totally ignorant of the history of other countries. We have spotlighted a few events. We have used our monarchs as milestones on the way but we have been so ill-informed on our history that the pride which was based on emotion has been too easily blown away by the partial criticisms that have prevailed.

A new look is required and the centre of the stage must be taken by the common man. Economic and social history must replace much traditional history and we must recognize that change is now so rapid that the happenings of this century must take precedence in the general education of our average pupils. There is no sign that countries are, as yet in any major degree, turning away from their own national history books but the United Nations Charter of Human Rights must be known as well as, if not better than Magna Carta. The social history of the century, and the industrial revolution must be seen as a continuing process across the world with evolving patterns of industrial relations. The trade union movements, the great socialist experiments, now perhaps beyond the experimental stage, are matters of greater moment than the amorous activities of Henry VIII. The historical novel can cope with our traditional history which no longer is justified in major demands on school time.

Geography, especially economic and human geography, deserves greater study and with the advent of film and television is capable of presentation in an ever more effective manner.

Travel must become a more purposeful and common activity. The school cruises organised by the British India Company in their school ships are already breaking new ground. It is surely of value to have a thousand teenagers walking and talking in the Kremlin and an equal number shattered by the poverty they find say, in Egypt or North-West Africa. The academic exchanges of students, traditional now in grammar schools and colleges, must be extended. A common job interest is a useful basis for exchanges. The metal workers of 1980 should be encouraged as part of their general education to have exchanges across national frontiers. This is still possible despite the unfortunate financial restrictions at present imposed on the English. In these activities the young worker may find some antidote for the depression which can attach to gainful occupations which involve repetitive, monotonous and not very stimulating activities.

In the matter of general education we must also be prepared to re-examine our concepts of literacy. A capacity to communicate orally may be no less important than a capacity to write clearly, especially in an age when speed requires a telephone rather than a typewriter. The message is more important than the method of its transmission. Schools might be encouraged to do more in this direction by inviting comments, heard and discussed by all rather than essays written individually, marked privately.

Our general education should attempt some appraisal of the use and meaning of words. The popular press is a ready-made text book. The emotive content of headlines, the careful selection of nouns and adjectives which allowed you to see your rebellion as a fight for freedom and your enemy's as sabotage. We have endured decades of discussion and dispute on the definition of offensive and defensive weapons, and words are used akin to weapons. The argument is not really one of size or function but of our personal position. The smallest gun, even the pea shooter, has both defensive and offensive potential. Standing behind it is defensive, standing in front it is offensive, if it is used it is both, if it is not used it is neither. This applies to the hydrogen bomb and to the water pistol. Workers who are majority voters must in a democratic society have a general education which provides this sort of objectivity.

Our general education should require a careful study of the press. A comparison of comments on the same events, a note of the degree of coverage, until the reader is released from the unconscious enslavement of his daily paper, (taken doubtless for the racing tip, the stock reports or the football commentaries), and adds to the editorial opinion the corrective factor for the established bias seen in a comparative study. It is an interesting exercise to imagine some happening and then get youngsters to write it up on the lines they think particular journals would adopt. This study of a range of newspapers may raise doubts as to the existence of absolute truth but more important is its tendency to liberate us from propaganda. Countries which have this range of reporting have an educational opportunity that should not be neglected.

The general education of the young worker should also accept the need to assist him in the establishment of his own home base. This is a complementary activity in which co-education can play an important part. I suspect that the future will be less willing than the past has been, to allocate activities between the sexes. There will be an increased sharing according to ability. The issue of sex itself needs to be dealt with positively and intelligently if by 1980 we are not to be over-run by the rackeeters. The so-called facts of life can be expeditiously dealt with for the average child at the age of eight or nine. Nor is it necessary to spend too much time on preliminaries with rabbits lest their conduct appear to him to be offered as an example. The act of reproduction can be simply and scientifically understood without emotional involvement. If this were cleared out of the way there would be a far better basis for dealing with adolescent problems, **the planning of a family and the proper** appraisal of a baby, i.e. the highest creative act of which a human is capable.

The practical chores of the home can be appraised and apportioned. The sooner a girl knows the difference between a chisel and a screwdriver the better. The more efficient a boy is in the kitchen the better his chances of a stable home. Much more attention might be given to these matters in some of our secondary schools. The impact of good teaching and training is already manifest in the emergence of workers' homes with taste, more civilised attitudes and more critical

This training is sometimes more difficult when the sexes are segregated in schools and an emphasis placed on academic pursuits as if academics were to have no domestic life. We need more married women on school staffs, and perhaps we have reached the stage when co-education should be the rule, and certainly the single sex staff room should become obsolete.

The pressure for certificates in education needs re-examination. In England it was, some years ago, necessary to pass in five or more subjects before a School Certificate was awarded. This has been changed so that a certificate in one subject can be achieved. This pandering to the desire to have every element of potential certificated has had unfortunate consequences. Formerly there was staff room consultation about Johnny Smith whose performance in several subjects was a concern of several teachers. Today the conversation tends to become an internecine struggle for additional time for each particular subject on the timetable, in which the total welfare of Johnny Smith can hardly survive. The general education of our children in a world of increasing specialization demands every effort to restore to the centre of our consideration the human individual.

In this development the individual must be encouraged to play his own positive role. We are, in England, rather slow in allowing our children to appraise their own work and the work of their contemporaries. For my part I would be content to let the children fill up their own report forms at the end of term. To be told by teachers that my son is slow and indolent in geography but keen and enthusiastic in history is no more helpful than to read that he thinks his geography teacher is dull and his history teacher smashing! The presentation of individual significance is an increasingly difficult task, as the whole concept of educational appraisal tends to move from concepts of perfection to concepts of normality. The "average" is an anti-progressive directive in our standardised society. Evolution owes more to the non-conforming than to the conforming.

Our general education has to find ways of correcting the technocratic, non-productive, trend. No less must it provide opportunity for flexibility and change. The metal worker of 1980 may have no metal to work in 2000 A.D. He must be ready to take up new materials, new processes and to this end we have to be to some extent in revolt against the standard practice and the done thing. This is not to suggest anarchy or perpetual **indiscipline,** but rather to point out that man himself, the animal, has in his evolution retained the primitive flexibility of five digits on his hands and the range of motion in his arms. The horse, whose ancestors began with this degree of potentiality has by concentration over the ages lost this flexibility. The splint bone marks the atrophy of lost opportunities. The evolutionary law is "you use it or you lose it". So man's tail has shrunk to his coccyx and his head swollen beyond compare. We need to examine what interests, what facilities we can ultimately afford to lose and what we must retain in the custody of what, for want of a better designation, we call general education.

VOCATIONAL EDUCATION AND TRAINING FOR THE FUTURE ON THE THREE STAGE SYSTEM

By Georg BENZ,
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The present system of vocational training in the Federal German Republic no longer meets the requirements imposed on individual employees by the economy. There is an ever increasing gap between vocational training and the subsequent exercise of a profession.

Thus we note that well over 50 per cent of employees in Germany exercise a profession other than that for which they were trained. In other words, they are either untrained or very imperfectly trained for the position they now hold. A 1964 sample census by the Federal Office of Statistics reveals that:

50	per	cent	of	trained	fitters
47.4	"	"	"	"	toolmakers
58.4	"	"	"	"	automobile mechanics
38	"	"	"	"	lathe hands
51.9	"	"	"	"	mechanics

are no longer practising their originally acquired skill. What is more, the percentage of specialists who have switched to an occupation in a related field is even smaller.

In the previously mentioned five occupations an average of nearly 20 per cent of all job changers are employed in a skilled or technical occupation. Thirty per cent of all trained personnel are today in occupations quite unrelated to their acquired skill.

There has been a substantial increase in this job changing in the last three years, particularly on a regional scale, due to significant economic and structural changes. We can safely assume that, today, two-thirds of all employees have changed their profession. It should also be stressed that a great many of the "job changers" have already changed their occupation several times.

The rapid development of trade, science and industry no doubt imposes a constantly changing employment pattern. Such structural changes may be observed in all industrial societies. In the Federal Republic the fact that adolescents are often channelled into a vocational training which is of little use to them later in securing a job, only emphasizes this tendency. They are therefore forced to change their occupation.

More rapid technical and economic development calls for greater occupational mobility. Vocational training must respond to this occupational mobility and prepare the individual to meet constantly changing occupational requirements. The present theory and practice in vocational training in the Federal Republic of Germany is, in most cases, directly contrary to these requirements. This is due to the structure and the content of the respective vocational training as well as to the fact that vocational training of apprentices in the Federal Republic is not run by the State but by the employers' institutions. Each factor reacts on the other.

The first objective of the proposals for vocational training by stages is the reform of the training system and the training curriculum. To get a clearer picture it is necessary to examine once again the guiding principles of vocational training in Germany. We need to remember, however, that these principles are being partly discarded in the latest methods of vocational training. They are, however, still valid for between 80-90 per cent of all apprentices.

The basic principles are as follows:

All branches and subsections of economic activity have their own specific occupations. This principle has led to the present number of over 500 occupations requiring prior training and such fragmentation cannot but lead to over-specialization. This means that, when an adolescent finishes compulsory schooling (at 14-15 years of age) he is obliged to select one out of a large number of occupations. In other words he begins to specialize at the very start of his vocational training.

In theory, all vocational training lasts between three and three-and-a-half years; this applies to industrial, trade and commercial occupations, whether bricklayers, plant fitters, lathe hands, commercial administrators, electricians or bakers. Even though the trade requirements are widely divergent, 90 per cent of male adolescents have to submit to such a "standard vocational training period" after full-time schooling has ended. This automatically results in a change in occupation and standards immediately after the apprenticeship period. Because both apprentices and firms are aware of this, the quality of the training inevitably suffers.

A standard training period of this sort also fails to take into consideration the different individual assimilative capacities and the varying conditions offered during training. The period remains the same whether the training centre is efficient or otherwise, whether the apprenticeship takes place under model conditions or is conducted at construction sites.

The basic dogma for training in the Federal Republic lays down that "Apprenticeship must be closely linked to actual work, if possible it should take place at the factory itself, in their production or repair departments. Therefore one must not dictate what training course the firm should provide and it is enough if the content of the training (knowledge and craft) is briefly outlined. From there on the firm will know how best to proceed ...".

This maxim might have been true in the past, but nowadays its consequences are impossible to justify. While technical development progresses, vocational training for a specific job in a firm deteriorates. Since every firm works to make a profit, vocational training requirements are subordinated to monetary considerations with the following particularly unfortunate consequences.

1. Vocational training at the factory level is conditioned by the orders that happen to be at hand. A systematic training progressing from the simple to the complex and from general to specific matters is thus jeopardized.
2. Every enterprise uses its "own methods". It has indeed been confirmed that theoretical and practical training differ widely in comparable enterprises.
3. Since vocational training is a reflection of the life in the factory, every measure of making methods more efficient is bound to work to the detriment of

vocational training. As a result an already far too fragmented apprenticeship system becomes even more specialized.

4. The apprentice is not being taught but learns by "helping and observing". The more complex, abstract and delicate the tasks are, the less the apprentice learns by simply helping with the work.

It can also be said that the guiding principle of vocational training is now largely out of date. This leads to wastage, faulty training and occupational blind alleys and destroys the adolescent's willingness to learn. Moreover, these principles are a bad investment for the national economy.

Vocational training by stages

Educators, vocational training instructors and trade unions in Germany have tried for over 20 years to work out proposals and plans to provide a systematic and rationalized vocational training more suited to the aptitudes and talents of the adolescent and the requirements of the economy.

When these proposals were revised, the idea of vocational training by stages gained more and more support.

Trade Unions and Employer's Associations who monopolize all vocational training have, at first, either rejected or ignored vocational training by stages. It is easy to see why. A modern training by stages can be achieved only by a thoroughly planned programme carried out over a long time in specially planned training centres. Since most enterprises do not, however, possess either special training centres or premises and as apprentices in most firms are expected "to help" rather than to be trained systematically, vocational training by stages could come about only by making radical changes of present-day practices.

It would be more logical first of all, to combine the requirements and skills needed in current vocational training into a precise and detailed curriculum and then to make firms agree to teach their apprentices these requirements and skills in their right sequence; most firms however still insist on doing the opposite. What they want is a relatively unspecific vocational curriculum which can therefore be followed by most companies.

The courageous and progressive support of the Krupp enterprise for vocational training by stages is therefore particularly significant. Introducing the scheme at first at their training centre at Essen, they were the first important enterprise to point out that the traditional system of apprenticeship no longer meets present-day standards. This constituted a major breakthrough. Krupp's example was followed by many other firms with their own vocational staged plans but no government recognition has yet been given to vocational training schemes by stages.

To avoid the danger of dispersed, unco-ordinated and uncommitted experimenting with vocational training by stages, and to establish a solid basis for this new form of apprenticeship, I.G. Metall submitted a memorandum on 13th November, 1966, to the Federal Minister of Economics, requesting official recognition for their "Plan for vocational training by stages" worked out by their commission of experts assisted by prominent vocational training directors. This plan contains all the essential requirements of a modern vocational training scheme. It leads to a more systematic and rational vocational training in the firm; leads to a complete and independent qualification, which corresponds to the requirements of the firm as well as to the aptitude of the adolescent; it is flexible, facilitates co-operation between firm and vocational training centre and terminates in a revised version of the outmoded final examination.

The curriculum of the first stage is identical for all adolescents irrespective of their future specialized training. It consists of two parts. The first is concerned with the basic skills of metal processing; and the second part offers a basic apprenticeship aimed at a specific occupation. This includes the operating of machines, alloying techniques using heat, heat-treatments, electro-treatments and metal bonding. In this way the adolescent becomes familiar with the various metal processing tasks, and is able to find out his particular aptitude so that after completing the first stage he is able to make his choice accordingly. It was for this reason that simple electro-treatments were incorporated into the first stage. This measure facilitated the subsequent training for electricians. At the same time, this type of work is worth knowing about anyway, if only from the industrial safety aspect.

After ten months' training the trainee is given an aptitude test which determines whether and in what special group his training should be continued during the second stage. The aptitude test is not just an examination but must take into account all previous records of training in the firm and in school. In order to avoid any wrong decisions, if a trainee appeals against the result the test must be repeated before the first year of apprenticeship ends.

The second stage combines, in five special groups, the most important fitter/mechanics occupation, machine tool operators and electricians. Each specialized group receives a broad training - such as is customary in the specific training centres and apprenticeship environments. Lathe-hand, cutter and planer all belong to one group of specialized machine operators. The second stage comprises all necessary basic and simple functions. The content and scope of this training are so devised as to lead towards a suitable last stage for the course, while at the same time constituting a valuable base for the next stage. Whether this stage can be entered, depends on a judgement of the apprentice's qualifications obtained after 20 months. Here too, so as to avoid mistakes, the decision may be appealed against by the apprentice. In such cases a reconsideration of the candidate's qualification takes place before his second year of apprenticeship ends.

When adolescents have finished the second stage of their training they are skilled workers. Modern methods, proper programming and planning make it possible to teach the whole curriculum in only two years.

In the third stage, the training is continued up to the level of qualified specialist. The relevant job-profiles provide an approximate guideline. In contrast to the old apprenticeship system, the third year is devoted not only to applying and enlarging the skills already practised, but especially to systematic instruction of new specialized skills and knowledge.

Vocational training by stages according to the "Plan for vocational training by stages in the metal trade" has the following important advantages over the old system.

1. It gives every adolescent a chance to receive a training corresponding to his wishes and aptitudes. It therefore takes account of aptitude and the possibilities of employment. Apprentices who might at first sight seem unsuitable, are no longer automatically excluded from training but given a chance to prove themselves. So-called "late developers" are thus at a lesser disadvantage.
2. Vocational training biassed towards a particular trade will make a correct decision easier for the adolescent. The grouping of similar trades also makes the choice of a specific job easier. Aptitude tests and examinations before the training can largely be dispensed with, since during the first stage there is ample opportunity for the apprentice to show what he can do.
3. A broadly based training results in greater mobility later on. It therefore meets the requirements of adaptation and continual further training for the more gifted employees.
4. Vocational training centres and firms can more easily be co-ordinated within a system of training by stages than would otherwise be possible in view of the great variety of individual vocations and vocational training schemes.
5. The training system by stages is able to produce better results. A specific curriculum obliges the trainees to follow a systematic and methodical training and dispenses with any unnecessary chance work. Since adolescents are admitted to each stage only once they have proved their aptitudes, failure in a particular exam can be avoided. As no unsuitable candidates are accepted training can proceed at a quicker pace.
6. Present-day final apprenticeship exams are nothing but a display of a set skill. With training by stages where aptitude for basic skills has to be proved in the very first stage and mastery of more complicated tasks in the second, there is an opportunity for more meaningful, objective and functional tests.

7. Each stage comes to a self-contained and definite end. This avoids the distinction made between vocational trainees and apprentices which has worked to the psychological detriment of the latter.

It should once again be emphasized that, correctly carried out, training by stages precludes all dangers of too early specialization as an apprentice. Unlike conventional apprenticeship, training by stages replaces haphazard instruction by planned teaching of skills and knowledge. Any technique new to the apprentice is explained to him together with all the relevant theory. Thus the apprentice is able not only to do the actual work manually but also knows why he is doing it in one specific way and not in another. He is taught not only "how" but also "why". In this way the apprentice learns to approach every new task systematically not by "feeling" or "experience" but with the aid of objective analysis.

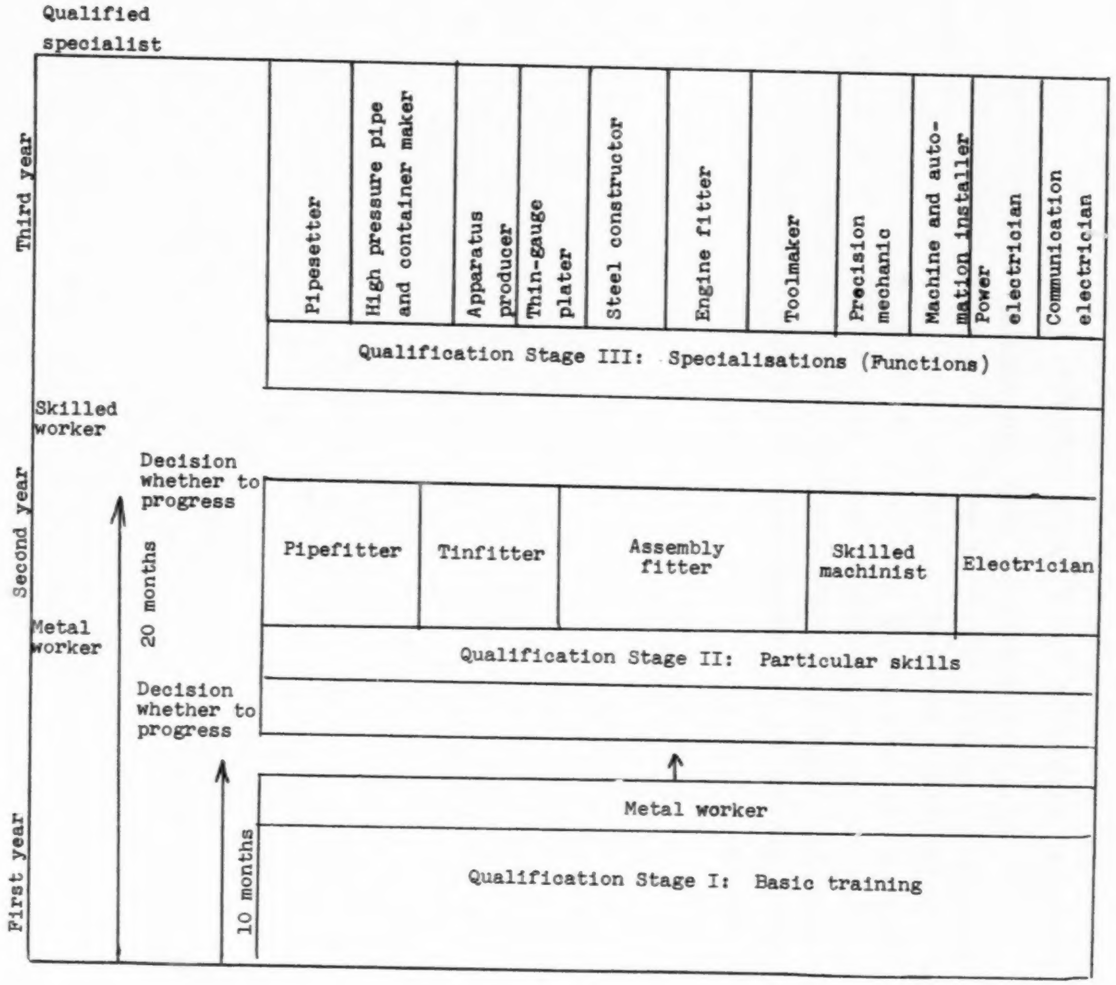
A well planned teaching and learning method takes account of the constantly growing demands in each vocational sector. Together with the transmission of broad knowledge and skills, vocational training by stages prepares the apprentice for greater mobility and flexibility and conditions him for further permanent retraining during his professional career.

The outlines of the proposed I.G. Metall "Plan for vocational training by stages for the metal trade" and the "Krupp's framework plan for vocational training by stages" are roughly identical. Both insist on basic training for all related trades at the first stage and both envisage a "trade-orientated" general training. Both advocate three progressive stages of which Stage II corresponds to the "average skilled worker" in both plans. The differences occur with the incorporation of electrical trades and the ramifications of Stages II and III. These differences do not however seem due to basic professional divergencies of opinion, but rather to the fact that the two plans start from a different premise. The Krupp plan is based essentially on the experiences and requirements of a single large undertaking while the I.G. Metall proposal is designed as a model for the entire metal trade.

The purpose of plans for training by stages is to re-organise the apprenticeship system in the firm. But their use is by no means restricted to the firm. On the contrary, staged training opens up new perspectives for a meaningful co-operation on vocational training in-plant training, training at inter-firm level, and training in vocational schools. Each individual stage can be taught, according to need and to capacity, either in the firm or outside.

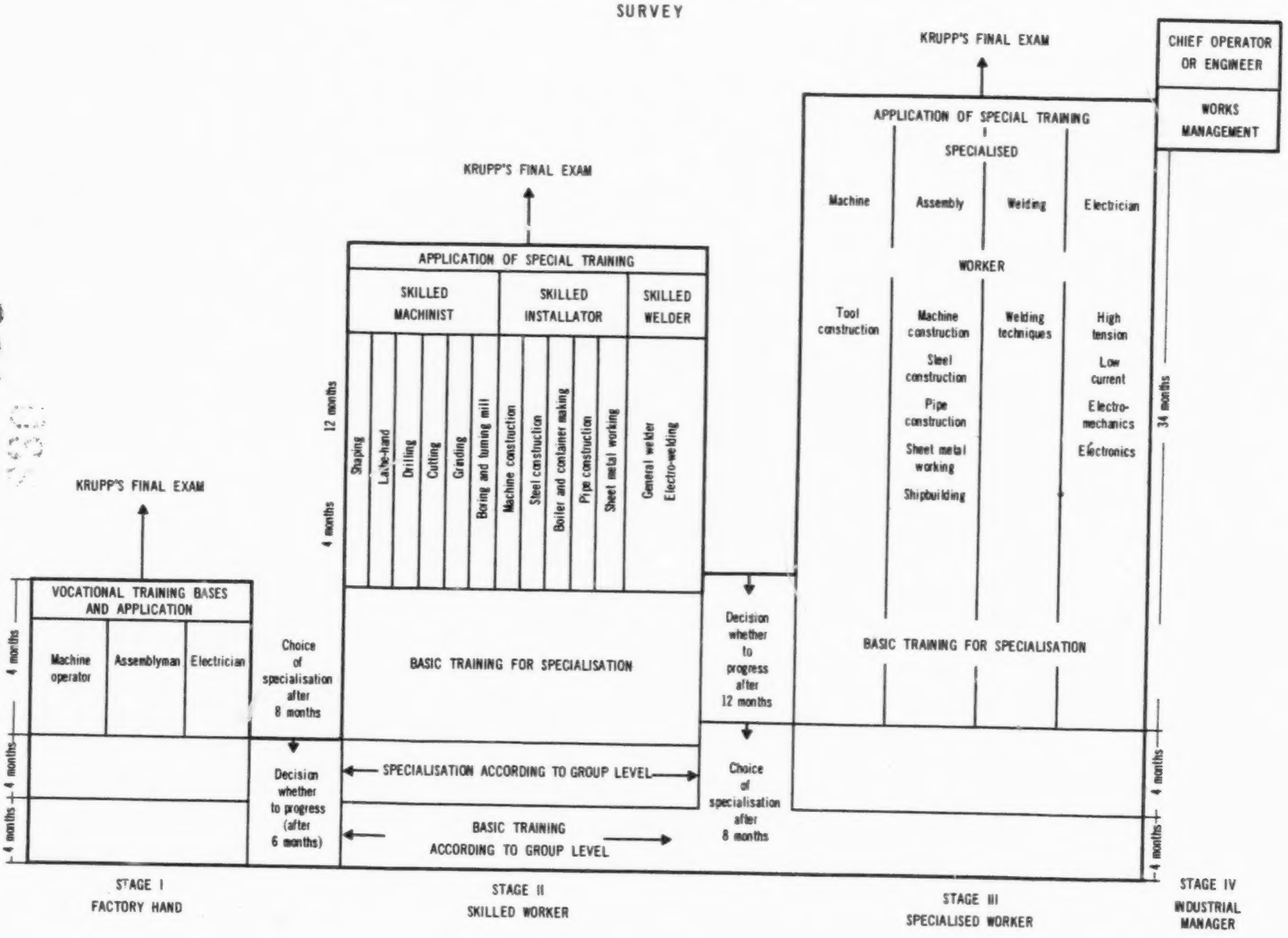
Staged training is only one medium to adapt vocational training of adolescents to present and future requirements. As a complementary measure, a changed school system, with at least ten years of compulsory education is required. Above all, it will be necessary to reform basic legislation so as to give all concerned - employer, employee and State - an equal chance of participating in the supervision and shaping of vocational training.

PLAN FOR VOCATIONAL TRAINING BY STAGES - METAL TRADE


Qualified specialist
Third year
Skilled worker
Second year
Metal worker
First year
Decision whether to progress
20 months
Decision whether to progress
10 months
Pipesetter
High pressure pipe and container maker
Apparatus producer
Thin-gauge plater
Steel constructor
Engine fitter
Toolmaker
Precision mechanic
Machine and automation installer
Power electrician
Communication electrician
Qualification Stage III: Specialisations (Functions)
Pipefitter
Tinfitter
Assembly fitter
Skilled machinist
Electrician
Qualification Stage II: Particular skills
Metal worker
Qualification Stage I: Basic training

KRUPP'S FRAMEWORK PLAN FOR VOCATIONAL TRAINING BY STAGES - METAL TRADE

SURVEY


KRUPP'S FINAL EXAM
CHIEF OPERATOR OR ENGINEER
WORKS MANAGEMENT
APPLICATION OF SPECIAL TRAINING
SPECIALISED
Machine
Assembly
Welding
Electrician
WORKER
Tool construction
Machine construction
Steel construction
Pipe construction
Sheet metal working
Shipbuilding
Welding techniques
High tension
Low current
Electro-mechanics
Electronics
BASIC TRAINING FOR SPECIALISATION
34 months
KRUPP'S FINAL EXAM
APPLICATION OF SPECIAL TRAINING
SKILLED MACHINIST
SKILLED INSTALLATOR
SKILLED WELDER
Shaping
Lathe-hand
Drilling
Cutting
Grinding
Boring and turning mill
Machine construction
Steel construction
Boiler and container making
Pipe construction
Sheet metal working
General welder
Electro-welding
12 months
4 months
BASIC TRAINING FOR SPECIALISATION
KRUPP'S FINAL EXAM
VOCATIONAL TRAINING BASES AND APPLICATION
Machine operator
Assemblyman
Electrician
Choice of specialisation after 8 months
Decision whether to progress (after 6 months)
SPECIALISATION ACCORDING TO GROUP LEVEL
BASIC TRAINING ACCORDING TO GROUP LEVEL
Decision whether to progress after 12 months
Choice of specialisation after 8 months
4 months
4 months
4 months
4 months
4 months
STAGE I
FACTORY HAND
STAGE II
SKILLED WORKER
STAGE III
SPECIALISED WORKER
STAGE IV
INDUSTRIAL MANAGER

VOCATIONAL EDUCATION AND TRAINING FOR THE FUTURE

THE MODULE SYSTEM AS DEVELOPED FOR THE ENGINEERING INDUSTRY IN GREAT BRITAIN BY THE ENGINEERING INDUSTRY TRAINING BOARD

by Alan **SWINDEN**
Engineering Industry
Training Board
United Kingdom

HISTORICAL BACKGROUND

The Industrial Training Act, which became law in March 1964, was the first Act of Parliament since the year 1563 to be concerned with industrial training. Its predecessor - the Statute of Artificers - although more immediately concerned with what would now be known as industrial relations and with the obligations on employer and apprentice rather than with training, was nevertheless a piece of legislation of immense practical and social significance, and it remained on the Statute Book until repealed in 1814.

Apprenticeship has for long served as the principle system of skilled training in Great Britain; but after the second World War, Great Britain faced an increasing shortage of skilled manpower and the system of apprenticeship could no longer provide adequate numbers of skilled workers, able to cope with technological innovations. At the same time the post-war increase in the population presented the prospect of a substantial bulge in the number of school leavers. Firms which had trained their own personnel for many years grew increasingly concerned at losing their trained labour to other companies. Employers more and more recognized that their own efficiency and productivity were directly associated with the ability and technical performance of the people they employed. This led in turn to the introduction of measures within firms to improve both the standards of training and of education of the people working for them.

Towards the middle and late 1950's, it became clear that training could involve many processes needing an organisation and structure that was bigger than the average firm. In this way there grew up various national associations, employers associations and professional groups, all aimed at developing training facilities

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in order to go beyond the limits of the training which an individual employer might be able to give. This was at least a move in the right direction but there was still no effort being made on a nation-wide scale beyond the basis of an individual industry. The system that had evolved itself relied on the goodwill and the voluntary efforts of individual companies in the industry. The pattern of training standards was far from uniform. There were those whose training arrangements were very comprehensive and a very large number who did no training at all but relied for their skilled manpower on a system of haphazard poaching from those firms with good training arrangements. In between these extremes lay the greater part of industry.

In an effort to resolve these problems the Government set up a Committee under the Chairmanship of Mr. Robert Carr, M.P., to investigate the nation's industrial training system and to make recommendations for its improvement. The 1958 Report of the Carr Committee re-affirmed the position that:

1. training was primarily the responsibility of industry;
2. the apprentice system should be retained;
3. the Government should concentrate its efforts on the expansion of the nation's system of further education.

In its own words the Report did, however, acknowledge that:

> "neither is the cost of training fairly shared by firms, nor is the amount and quality of training being done in the country enough to keep pace with the rapidly changing development and the rapidly changing technology which we need in order to keep ourselves alive in this country".

The Report recommended the creation of a voluntary national apprenticeship council to encourage employers to provide training and to increase the number of apprenticeship openings for school leavers. In 1958 the Industrial Training Council, representative of employers and trade unions, was set up to accomplish these purposes, but despite valiant efforts and much useful work to condition people's minds to the need for change, the five years that followed saw the situation over the supply of skilled manpower grow steadily worse. By the end of 1962 it was apparent that a major intervention by the Government was going to be needed.

The Government's proposals for industrial training were embodied in a White Paper in December 1962. The White Paper proposed the creation of training boards with a responsibility for setting training standards, and comprising representatives of employers and employees together with representatives from the field of education. With this tripartite body would sit assessors from Government departments. It also outlined a method of collecting a statutory levy from firms and of paying back by way of grant either less, the same or more than the amount collected in the levy, according to the amount of training being done and the quality of that training.

The Act, which in March 1964 grew out of these proposals, involves training boards with training at all levels within industry; that is to say with the training of managers and supervisors, technologists and technicians, as well as skilled, semi-skilled and unskilled workers. It applies to persons of all ages and of both sexes, including the training, retraining and further training of adults.

DEFINITIONS

The terms skilled, semi-skilled and unskilled for manual workers are traditional to the engineering industry and are meaningful primarily in the field of industrial relations. That is to say they denote spheres of activity which have been established by custom and practice and they are associated with negotiated basic rates of pay. In training terms, however, they are not sufficiently precise. A trainee who has served a formal apprenticeship between the ages of 16 and 21, as laid down in the agreements existing between the employers and the unions, becomes a skilled man, but not all men accepted as skilled in terms of rate and job have served a formal apprenticeship. Similarly there are regional differences in the acceptance of what jobs are for skilled men only and what may be undertaken by the semi-skilled.

The jobs of all workers embody a degree of skill. It has been found more appropriate therefore not to use this terminology when seeking to identify people in training terms. Instead the terms craftsman and operator are used.

The craftsman is employed in an occupation for which a worker would usually have qualified after receiving a recognized period of apprenticeship or equivalent training, and he is capable of undertaking a range of work involving a broad range of skills.

The operator is normally employed on work demanding less breadth of knowledge and a narrower range of skills than that of a craftsman; in other words he would not work on jobs requiring training through apprenticeship or its equivalent.

WHY CHANGE THE SYSTEM?

The classic approach to engineering craftsmanship has been through an apprenticeship, the duration of which and age at which it would be served being laid down in industrial agreements between the employers and the trade unions. Commonly it has been of five years duration between the ages of 16 and 21 but there has been provision under certain conditions for the duration to be as short as four years provided it ended at 21. This system has over the years produced first class craftsmen. Why then should any change be made? There are three main reasons:

(a) Good training is expensive if it is to produce the men of high quality; hence it must be carried out as efficiently as possible using all the modern training devices available.

(b) The kind of craftsmanship required is changing because of the development of engineering technology.

(c) Trainees have a better education both before leaving school and afterwards at the Colleges of Further Education, so that they are capable of developing skills and technical knowledge more quickly and deeply than hitherto.

PRINCIPLES OF THE MODULE SYSTEM

The module system is based on eight principles:

(i) Flexibility

The system requires that trained craftsmen shall be able to adapt to technological and other changes. This implies that the training must be broadly based, and also that craftsmen are equipped with a range of specialist skills which they can use in a flexible way. It is also implicit that whilst all craftsmen must have a minimum level of attainment some will develop further to meet the requirements both of industry and the individual.

(ii) Length of Training

The length of training shall be based on what has to be taught and on the rate of learning of the individual, subject to sufficient time being allowed to acquire maturity. This means that there will be an incentive for trainees to become qualified as quickly as possible.

(iii) Standards of Craftsmanship

Standards of performance of craftsmanship will be set and will be recognized by certification when they have been reached.

(iv) Assessment

The attainment of approved standards will be measured by a system of tests. The tests will take place at intervals throughout the period of training, and will be used together with training records and log books as the basis of the award of certificates of craftsmanship.

(v) Further Development

There will be an opportunity for all craftsmen to acquire further knowledge and to add to their skills in accordance with industry's requirements. It is to be expected that whilst the initial training as a craftsman could be as short as three years, most craftsmen will need to return to the training system at intervals throughout their careers to learn new skills and to be brought up-to-date.

(vi) Instruction

Formal instruction of trainees in practical skills will be given by skilled people who have been trained in the techniques of instruction. Full advantage is also to be taken of modern teaching aids such as programmed learning devices, instruction manuals, and audio/visual systems.

(vii) Further Education

Throughout the period of training, release will be given on full pay for attendance at a College of Further Education for a matching course of study.

Release will be for at least one day per week during the college session (or the equivalent in block release), and those trainees who can benefit should be allowed to continue their studies after formal training is completed.

(viii) Status of Craftsmen

The new system will identify the craftsmen and enhance their status by requiring approved programmes of training, recognized standards of performance, certification and registration.

THE NEW STRUCTURE

The training of craftsmen in future will contain three main elements which are:

(i) A first year of basic training in a wide range of skills carried out off-the-job in a training workshop or a place set aside for training and away from production. They must be under the guidance of full-time instructors.

(ii) Selected training in specialized skills under controlled conditions. The skills are chosen from a number of training packages or "modules" as they are called, and control is exercised by the Training Board through prescribed training specifications, instruction manuals, trainee log books and a system of tests. At least two modules must be followed successfully before craftsman status can be achieved.

(iii) Experience in using the skills learned in an industrial environment in order to develop them to approved standards. Experience will be interspersed with module training and the required standards of performance will be measured by testing.

Each scheme of first year training consists of three parts:

Part A: Induction, which lasts for three months, to act as a bridge between school and industry by providing an introduction to the safe ways of work and instruction in hand skills.

Part B: Acquisition of basic skills: to provide the main groundwork in the skills of manipulating and forming metal and other engineering materials using hand and machine tools.

Part C: Initial development of special skills: to develop confidence in using basic skills to make engineering products in one of the fields of mechanical, electrical and electronic, forming and fabrication, instrument engineering or vehicle building.

On the successful completion of first year off-the-job training, trainees are awarded the Engineering Industry Training Board Certificate of First Year Training and become registered with the Board as trainee craftsmen or technicians.

The following diagram illustrates the pattern of craft training after the first year. A large number of modules of training is available in different skill specialities, and the choice is made depending on the needs of the firm and the potentialities of the trainee. The diagram is not intended to be a final statement since new modules will be added to keep pace with changing technology and the needs of industry so that amendments will be issued from time to time.

For each module of training, the Board provides:

(i) A skill specification indicating the range of skill to be developed during training and the standards to be reached at its completion.

(ii) A training specification setting out the details of the training to be given.

(iii) An instruction manual indicating methods of developing each element of skill contained in the training schedule.

(iv) A set of sample performance tests which are to be completed successfully during the progress of the training.

(v) A recommendation for further education.

(vi) A log book in which the trainee records the training received.

STRUCTURE OF CRAFT TRAINING

THREE YEARS MINIMUM

Stage I Basic Training 12 Months	Stage II Module training period 6 months approximately		Necessary qualifications for starting Stage III	Stage III Module training period 6 months approximately	
FIRST YEAR TRAINING	**FABRICATION ENGINEERING PRACTICES**				
	Thick Plate Working I	D.1	D.1	Thick Plate Working II	D.21
	Thin Plate Working I	D.2	D.2	Thin Plate Working II	D.22
	Pipe and Tube Fabrication	D.3			
	Spinning	D.4			
	VEHICLE BODY PRACTICES				
	Vehicle Painting I	E.1	E.1	Vehicle Painting	E.21
	Vehicle Body Building I	E.2	E.2	Vehicle Body Building II	E.22
	Coach Trimming I	E.3	E.3	Coach Trimming II	E.23
	WELDING PRACTICES				
	General Welding and Cutting	F.			
	Oxy-Fuel Gas Cutting and Gouging, Arc Cutting and Gouging	F.1			
	Tungsten Arc Gas Shielded Welding	F.2	Any two of F.2 to F.5	Advanced Pipe and Tube Welding	F.21
	Metal Arc Gas Shielded Welding	F.3			
	Manual Metal-Arc Welding	F.4			
	Oxy-Acetylene Welding	F.5			
	ELECTRICAL & ELECTRONIC ENGINEERING PRACTICES				
	Static Electrical Equipment Winding and Building	G.1	G.1	Static Electrical Equipment Testing	G.21
	Rotating Electrical Equipment Winding and Building	G.2	G.2	Rotating Electrical Equipment Testing	G.22
	Electrical Fitting I	G.3	G.3	Electrical Fitting II	G.23
	Electrical Assembly and Wiring	G.4	G.3 or G.4	Electrical Inspection	G.24
	Electronic Equipment Wiring and Assembling I	G.5	G.5	Electronic Equipment Wiring and Assembling II	G.25
			G.5	Electronic Test and Inspection	G.26
	MECHANICAL ENGINEERING PRACTICES				
	Machining for Toolmaking and Experimental Work	H.1	H.1	Press Tool Making	H.21
	Turning I	H.2	H.1	Die Making	H.22
	Mechanical Fitting I	H.3	H.2	Turning II	H.23
	Milling I	H.4	H.1 or H.3	Instrument Fitting	H.24
	Grinding	H.5	H.1 or H.3	Mechanical Fitting II	H.25
			Any one of H.1 to H.5	Inspection and Measurement	H.26
			H.1 or H.2 or H.4	Jig Boring	H.27
			H.1 or H.2 or H.4	Boring	H.28
			H.4	Milling II	H.29
			H.1 or H.2 or H.4 or H.5	Machine Tool Setting	H.30
	MAINTENANCE ENGINEERING PRACTICES				
	Mechanical Maintenance I	J.1	J.1	Mechanical Maintenance II	J.21
	Electrical Maintenance I	J.2	J.2	Electrical Maintenance II	J.22
	Maintenance of Factory Services I	J.3	J.3	Maintenance of Factory Services II	J.23
	Electronic Maintenance I	J.4	J.4	Electronic Maintenance II	J.24

EXPERIENCE

EXPERIENCE

* Where training is restricted solely to Welding, three modules must be taken, the first of which must be General Welding and Cutting.

At the end of the first year course of training a choice is made of one or more Stage II modules on the combined basis of the firm's need and the trainee's aptitude. Training in the chosen module will proceed in accordance with the appropriate training specification and to the standards prescribed by the skill specification. During the training the work carried out will normally consist of items of production which have been carefully selected by the training staff in consultation with the production departments to give the range of training prescribed. Periodic testing in accordance with the prescribed standards must be carried out. Module training may take place on or off-the-job, but in all cases it will be a requirement for recognition of approved training that the trainee is responsible to a trained supervisor.

Following the completion of one Stage II module a trainee may proceed to a related Stage III module or alternatively complete a second Stage II module. The minimum requirement for any craftsman (except Welding - see note on diagram) will be the successful completion to the requisite standard of any two modules, one of which must be at Stage II. The diagram illustrates the necessary qualifications for entry to each particular Stage III module.

In support of each module of training completed, a period of controlled experience is necessary in a production environment to practise the skills acquired. The main purpose of the time spent on experience is to gain maturity and dexterity under the industrial pressures of cost and time. The experience in practising the acquired skills must be planned carefully in order to cover the maximum range, and the work done during this phase must also be entered by the trainee in his log book and certified by his supervisor. The last of the tests will be carried out at the end of the period of experience when it is judged that the trainee can reach the required standards of performance in accuracy, quality and time.

Many craft trainees will be able to reach the minimum satisfactory standards of skill by the end of their third year of training. Some might continue with further modules of training, and it should be understood that additional modules can be undertaken by any craftsman at later stages in his career.

THE FUTURE

Under the Act, training boards have a duty to do everything in their power to ensure that people are trained for the requirements of the industry which they serve. It has been stated that in order to bring this about a board should first undertake manpower planning and then plan the training for the people who will be required. Were such a procedure wholly practicable it would, of course, be ideal. In practice, however, such a solution presents great difficulties, especially if the necessary enquiries are taken down to the level of the individual firm. Many firms would find it difficult to forecast with accuracy the numbers and types of labour they would require in five or ten years time. This difficulty would come about partly because of changing technologies, partly because change is frequently imposed by circumstances beyond the control of the enterprise. The latter type of change comes about sometimes through take-overs and amalgamation of industrial concerns, sometimes through changes in the political climate.

The Engineering Industry Training Board has, however, commissioned two research projects - one to investigate the ways in which the overall shape and pattern of employment in the industry might be determined for the future, another on the likely changes which may come about due to changing technology. Meanwhile the keynote of the Board's training recommendations in general and of the module system in particular is flexibility - the flexibility which comes from a workforce endowed with a range of skills capable of meeting a changing need and able to realign its skill to meet the demands which it may be called upon to display.

The introduction of the module system and its development in Great Britain represent change in the traditional method of training - change which calls for understanding of the industrial relations problems involved. In this respect trade unions and employers have shown a real appreciation of what is involved and there is every indication that in the interests of the future well-being of the industry such difficulties as may arise will be overcome. Work is going ahead with urgency and determination on the preparation of training specifications and instruction manuals, and it is anticipated that a wide range of pilot experiments in the new system of training will be started in the year beginning September 1968. The general introduction of module training is planned for the autumn of 1969.

During the course of the work being undertaken by the Training Board, close relationships have been established with the Bemetel Foundation of Holland and Sveriges Verkstads**forening** of Sweden and an agreement for a full and free exchange of information and for mutual co-operation in future planning has been established between the three parties. Of particular value to the Board is the knowledge and experience which has been accumulated in these two countries in the techniques of planned instruction and performance testing. As we move towards 1980 and towards closer industrial integration within Europe it is perhaps significant that the three countries - each with its own industrial relationships, with differing employer/trade union backgrounds and with different educational patterns - can find much in common in their approach to training.

Just as the training of craftsmen by the module system is being developed so is work proceeding on the improved training of operators. By the proper identification of the skill and knowledge required and by the planning of training programmes vast progress can be made. In Great Britain relatively little has been done in this field yet operators constitute nearly half the workforce. It is probable that there will be a great increase in this activity - in fact the potential benefits in economic terms both for employer and employee are so great **that this must come about.**

The value of skills analysis in relation to operator training has been known and understood for some time, though the advantage taken of it has been far less than it should have been. The projection of such work into the field of craft skills is now one of the most interesting and potentially fruitful training developments. The investigation into and identification of the skills which go to make up the traditional skilled or craft jobs may well transform the training methods of the future.

What then may we look forward to in 1980? Better trained craftsmen doing jobs worthy of their skill. Probably fewer of them, but more who in the past would have remained craftsmen becoming technicians to keep pace with technological change. Operators trained effectively and to greater purpose;

and above all greater flexibility so that both industry and the individual may gain by the proper use of ability and may benefit from the investment in education.

VOCATIONAL RETRAINING IN THE FUTURE

by W. Douglas SEYMOUR.

Preliminary Remarks

The formulation of any proposals for Vocational Retraining in 1980 presupposes:

1. A forecast of the social, economic and educational state of the European world at that date.
2. A forecast of the state of metal industry technology in 1980.
3. A clear idea of how people will have been trained prior to that date.

And these three subjects will be discussed as a preface to the main topic of Vocational Retraining in 1980.

1. The Social, economic and educational state of Europe in 1980

The recording of history has occupied chroniclers for innumerable millenia, and the interpretation of history comprises one of our most respected academic disciplines. The study of the remote past is not only fascinating but highly esteemed; the study of the present - or rather of that immediate past which we call the present - is less highly esteemed, less common and often less interesting.

The prediction of history is much less respectable than either its recording or its interpretation. **Foretelling the** future is even more uncertain than describing the past, and although prophecies and divinations have fascinated people (and especially rulers) throughout the ages, the role of prophet was always insecure (I don't think they ever succeeded in establishing a trade union for **soothsayers**).

So writing about the future is usually confined to the realms of fiction, whether in the form of science fiction which has gained such enormous popularity, or social and political fiction, as exemplified by George Orwell's 'Ninteen Eighty-Four', and Aldous Huxley's 'Brave New World'. We are now about half way through the period over which Orwell was forecasting (1948 - 1984) and so we can begin to see whether the trend is in line with his graph. Certainly in many countries which George Orwell knew as democratic there has been a distinct move toward more authoritarian government, and military or semi-military governments have reappeared not only in Europe but in Africa, India and in other developing countries. Militarism, and the expenditure of an enormous proportion of gross national product on armaments has certainly, alas, developed in the way Orwell foretold, but liberal attitudes and free speech still persist in varying degrees.

Conditions of life in 1980 are perhaps a little more predictable. It is to be hoped that by then we shall have learned how to live with the motor car, and to avoid the congestion which bedevils life in our larger cities today. If there is no major war, domestic buildings will doubtless have become even higher; if there is, they will probably have gone deeper and deeper into the ground. Domestic mechanization should by then have spread to all households, and an even greater proportion of industry be devoted to the manufacture of household semi-durables. One hopes that the problem of noise will have been tackled as energetically as the problem of air pollution is being tackled in some countries today, and that people will be enabled to enjoy clean air in quiet surroundings.

By 1980 education in Europe should have developed into a much more pervasive and more integrated influence than, in many countries, it is today. By this I do not just mean education up to the age of 16 or 21; the most important change would be for education to be recognised as a life-long process with no temporal limitations or boundaries. Moreover, it is to be hoped that education will by then have become more closely integrated with living. Throughout many epochs of civilization education has been concerned with the cultural and inessential aspects of life, and with the symbolic communication of such culture. Insofar as man's cultural life could begin only when his essential needs had been met, this was natural and inevitable. European education, with its strongly religious and monastic background in history, has tended to concentrate on culture and, in recent years, to form almost a part of the "escapism" from daily life as lived by the mass of people. Too often the degree of respect for academic studies has been equated with their remoteness from everyday life. Again, the activities of man which are determined by symbolic decision-making have, in the educational field, received much greater attention than those which are determined by non-symbolic decisions, and it is these which form the basis of industrial skills and technologies.

So education has for many been something remote from life itself - or at least, remote from earning a living. The industrial Revolution and the factory system which came with it brought great changes in the social context of work. The skills of making things were removed from domestic life, where under the system of cottage industry and the like, people were in daily contact with productive work, acquiring skills, whether as apprentices or otherwise, as part of everday life. In the nineteenth century the introduction of State education systems in most European countries brought further divisions, and learning became separated from living as living had been from working.

This double divorce is detrimental to the integrity of life in industrialised societies and it is sincerely to be hoped that by 1980 the use of mass media for education will have enabled Europeans to overcome this problem. Broadcasting, television, films and other mass media should by then be playing a vital part in reintegrating learning with living and living with working.

2. Metal industry technology in 1980

The vocational retraining needed in 1980 will depend upon the state reached in the technological development in the industries concerned, and also upon the rate of such technological change at that date. Precise prediction is impossible, and there are many speakers here far more expert than I am to forecast the future of metal industry technology.

It is assumed that by 1980 the greatest proportion of consumable products will be made by process industries or by automatically controlled machines. The manufacture of these machines, plant and equipment will occupy the greater part of the labour force engaged witnin the industry - including those who make the machines to make the machines etc. etc. It is also assumed that by then numerical control and other forms of predetermination will have removed most direct work.

It may be expected, however, that the substitution of other materials for metals will have proceeded very much further than it has today. Consumer durable products, domestic equipment and transportation equipment will presumably by then be very largely framed in metal but fabricated from substitute materials such as plastics and fibre glass, though by then totally new materials, more readily recoverable, may well have been invented. The present century has seen such a high rate of consumption of metals that we must accept the accusation of being a generation of waste makers. The disposal of waste metals in worn out machinery has already become a serious social problem, and this, no less than increasing shortage of available ores, will increase the demand for disposable materials in place of metals. By 1980 it is probable that all metals will have become sufficiently "precious" for their use to be restricted to situations where their strength etc. is essential. Machinery and moving parts of plant and equipment will probably still be largely in metals, with cladding of other materials.

Changes in other industries may well affect the need for and use of metals in plant and equipment made for them by the metal industries. This would be compensated for by the increased need for novel types of chemical and biochemical plant, thus necessitating further changes in the metal industries themselves.

It is thus probable that by 1980 the activities in the metal industries will consist principally of:

(a) Making and maintaining the plant, machinery and equipment used within the metal industries themselves.

(b) Making and maintaining machines, plant and equipment for other industries, including particularly the civil engineering and construction industries where the strength of metals will still be essential, and the transportation industries (e.g. particularly, prime movers).

and only marginally of

(c) Manufacturing products, though any product still made of metal by direct work will be highly important.

It is clear that the present trend towards more and more "process" type industry will continue and that men will be engaged less on direct "manufacture". Thus the maintenance of plant and machinery within the metal industries and for other industries will constitute the largest single source of demand for trained personnel from the metal industries and engineering, and retraining for this purpose will be constant and unending.

3. Training in the metal working industries prior to 1980

Retraining in 1980 will also depend upon the training which workers in the metal industries will have already undergone prior to that date.

Prediction in this area is a little less uncertain than in other areas of prediction concerned with our subject. Plans for the development of industrial training throughout the 1970's are already being formulated and indeed many of those who will require retraining in the 1980's have already received their initial training in the form of apprenticeships or other basic courses. One can assume therefore that those who will require retraining will have had at least such training as exists now or, more likely the sort of training which has already been outlined in the papers by Mr. Benz and Mr. Swinden.

At the craft level, apprentices will have undergone basic training, and training in a number of modules or areas of metal working skill, and such training will have been analytical and systematic, i.e. it will be based on an analysis of what the experienced worker does and how he does it, and will be systematic in the sense that learning situations for the apprentice will be organised and prearranged (usually off-the-job) and not occur haphazardly as they would with exposure training on the factory floor.

Similarly at operator level one can expect that systematic, analytical training methods will be employed, although the jobs for which people are trained will have changed appreciably as a result of increasing prevalence of process and automated industries. Likewise one may expect the training of technicians to have changed in the manner outlined by previous speakers.

An important factor affecting training in 1980 will be the effect of changes in manning. Since the second World War, we have seen great changes in training requirements arise not only from technological change but also from changes in manning - and indeed these two factors almost always interact. We have seen the manning of, for example, capstan lathes change from a set-up of setters and operators to one of setter-operators when much of the routine work was transferred to autos, and set-up changed again when automatic attachments replaced operators.

Similarly many of you will be acquainted with the manning changes which have taken place in process industries, as exemplified by the well-known Fawley experiments.

Manning changes will undoubtedly continue into the 1980s and will determine in part the amount and the sort of retraining which will be required.

4. The Retraining of Workers in 1980

The most important step to achieve by 1980 in the retraining of industrial workers will be the abolition of the idea of retraining altogether. By then we should have become so accustomed to change in industry that we do not think in terms of training and retraining, but of training and training and more training to meet the continually changing needs of industry. By then industry and industrial workers will, we hope, be thinking of work in dynamic and not in static terms, so that change of work and training for such change are regarded as normal. The traditional attitude - that a man learns a job or a craft prior to attaining manhood, and practises it for the rest of his life - is already outmoded in all the developed countries, and one may expect that by 1980 a new attitude - that change is inherent in industry, and that additional training goes automatically with change - will have become universally accepted. So by then training and retraining will not be conceived of as separate periods or ideas, but training will be viewed as a recurrent, intermittent series of periods in life by which one is equipped to deal with changes in work.

(In spite of these statements, the word retraining will continue to be used in its current sense throughout the remainder of this paper in order to avoid confusion with the terms used in other papers at this seminar).

The following features of such continuous training or retraining deserve consideration:

(a) The nature of the tasks and of task change

All industrial training needs to be considered on a task by task basis. All industrial tasks consist of a man-material relationship within which (with the exception of pure handwork) there exists an intermediacy of tools, machines or other complex systems. Man at work in productive industry strives to attain a change in the formation of material in his environment - change which in the simplest economies he achieves with his own unaided limbs. In slightly more developed economies, and for many millenia, he has done this with the aid of hand-tools - to take the material world and "remould it nearer to the Heart's desire". Modern productive technology is but the development of such hand-tools, elaborated to meet the more sophisticated needs which man develops with his ever-widening horizons and more widespread communication. Man's capacity as a toolmaker and tool-user is as important, and as specific to man, as his capacity to communicate in speech and in other symbolic forms. The great difference between technological development and communication development lies in the fact that the former depends principally upon non-symbolic decision-making (which is fundamental in human skills) and the latter upon symbolic decision-making. More sophisticated technologies thus involve more complex intermediacy between the worker and the material upon which he is working. But however advanced the technology, it will always involve relationships between man and material ranging from the simplest to the most complex. This is well exemplified in the use of computer-controlled machine tools, where the tool in the worker's hand is replaced by very complex systems, but the manufacture of the system - e.g. of a computer memory - requires pure handwork of the very finest delicacy in the wiring of the matrices.

Thus, however advanced the technologies which prevail in the metal industries in 1980, they will still be faced with the need to train people in all classes of industrial work i.e. in handwork, handwork with tools, single-purpose machine work, multi-purpose machine work, group machine work and non-repetitive tasks. In each of these the man-material relationship is recognizably different, and for each skill there is a different structure (Seymour 1966).

Although the total range of skills required in the 1980's may show little change, and although job changes are likely to give rise to the need for retraining in all classes of work, there is likely to be a marked shift in emphasis, as certain classes of work become more rare, and others more common. The features which are likely to acquire increasing importance are discussed in (c) below.

One general change in industrial tasks, which is already becoming manifest, may be expected to be almost fully developed by 1980 - namely, that resulting from economy of information storage and retrieval.

As stated above, the performance of industrial tasks involves an information flow between man and material with or without the intervention of machine tools or other systems. The importance of this information flow has too often been neglected in the past, with consequent failure to attain potential ergonomic improvement and reduction in training time. The storage and retrieval of such information is particularly difficult when all the information is non-symbolic, as with most direct manual work, but the worker, in order to become skilled, must needs learn how to detect, sense and perceive the information flow (most commonly in terms of knowledge of results). But where different workers perform the same tasks at different times there is usually a great waste of information, most of which can be symbolically recorded and retrieved by other workers. For example, when a try-out setter tests a set of press tools for the first time, he discovers a lot of "information" about setting those particular tools for that job. When he has satisfied himself that they will do the job, he puts the tools away till they are needed for production. The production setter comes along and usually has to determine this specific information or "know-how" all over again, because it has not been stored ready for him to retrieve it. It is sincerely to be hoped that long before 1980 such waste of effort will be eliminated.

Again, in the design of machine tools the organisation of the man-material information flow can often be improved, with consequent advantages to productivity and training. In numerous industries e.g. spring making, the setting of the machine is determined by the setter from the product. He makes a trial setting, produces a spring, tests and measures it, readjusts his machines and makes another spring, repeating this procedure till he is satisfied. This is clearly wasteful, and more modern machines are designed so that there is an information flow such that the product can be determined by the setting instead of the setting being determined from the product. The introduction of such improvements is expected to be universal by 1980 with consequent simplification of the retraining of setters to handle new machine tools.

(b) The analysis of the skills and knowledge involved in new tasks

As mentioned above it is anticipated that by 1980 all training and retraining will be both analytical and systematic. By then we may expect that the techniques of skills analysis - and indeed the whole technology of industrial training, of which it forms part - will have been mastered by many hundreds if not thousands of people who will be capable of applying them.

The elemental analysis of industrial skills is already reasonably well understood and is now employed by training specialists in almost all industrially developed countries. The structural analysis of complex industrial skills is as yet less generally understood or practised, and developments in this field may be expected to spread widely in the future. New tasks in industry may well demand new structures of skill, and a capacity to analyse these will be essential if the best retraining is to be provided. At this moment in time, however, it would appear that the methods and procedures of structural analysis already in use should serve for the future.

There are nevertheless numerous areas in skills analysis where by 1980 we need to make much greater progress. One of the most important of these - both currently and for the future - is the analysis of skilled performance in very fine work. Such work is becoming increasingly important, especially in the electronics industry where micro-miniaturisation is demanding finer and finer work. Here the capacity of the most expert workers to perform the tasks outstrips our present ability to analyse their skills. The fineness of the work performed at high speed with unaided vision suggests that the workers are not depending principally on vision itself - unless they have acquired a visual capacity not hitherto suspected. Alternatively they must have developed Kinaesthetic discrimination to an abnormal degree, and it is in this visual - Kinaesthetic co-ordination that much greater research is needed to aid in the analysis of fine work in the future.

Another area of ignorance where further research is needed - and, let us hope, will be available before 1980 - is in the analysis and understanding of the inter-relation of adaptation and discrimination in Kinaesthetic perception. Kinaesthesis - the sense of feel - is predominantly important in traditional handwork tasks and in handwork with tools, but is also equally important in many modern tasks in sophisticated industrial processes. Our knowledge of Kinaesthesis is much less well developed than that of the exteroceptive senses e.g. vision and hearing.

(c) Features of industrial skills likely to be increasingly important in 1980

There are numerous features of industrial skills which are likely to be of increasing importance with task changes. These are particularly:

(i) Perceptual skills and perceptual discrimination

Increased mechanization in manufacturing industry and the continued trend towards process - type industry reduces the dependence of the worker upon the motor activities which he performs, but correspondingly increases his relative dependence on recognizing essential cues and perceiving their meaningfulness. What the worker has to do becomes easier; how he knows when and what to do becomes more difficult. The capacity to appreciate very small details in machine and plant situations and the capacity to make speedy and correct decisions therefrom will increasingly become the predominant feature at which retraining will need to aim. The activities to be performed by workers on automatic assembly lines or transfer machines are relatively easy, but determining when they need doing, or are best done, still depends on speedy and acute perception, without which production may be jeopardized. The importance of these perceptual skills is all the greater because they are highly specific to the particular systems where they apply and as workers move from one plant to another, or from one piece of automatic plant to a newer one, fresh, highly specific cues need to be recognized and their meaningfulness learned.

The retraining of workers in such tasks will be facilitated as the importance of the perceptual component in industrial skills becomes more generally appreciated and here the mass media (television etc.) will be able to make a unique contribution to industrial training by enabling all members of the public engaged in industrial work to appreciate the features of skill and human performance which are important in their jobs, and how the human operator develops these skills.

The perceptual discrimination required in future tasks may also be, in certain cases, of a higher level than that required in current work. For this, more specific perceptual retraining will be required, especially if we find that man is capable of levels of discrimination as yet unused and unrecognized. But the fundamental procedures for retraining in such cases are likely to be still the same and to depend upon an analysis of how the most successful workers derive the information from specific cues.

(ii) Control Skills

The continuing trend towards more and more process-type industry will enhance the need for control skills and much of the retraining in the 1980's will be concerned with such skills. The essential features of control skill have been analysed by Prof. Crossman and described in (inter alia) papers read to earlier conferences in this series.

Here again there are areas where further research is needed. For example, the basic studies which Crossman has outlined on human capacity for strategic decision-making in process control situations need further development, not only for training purposes but also from the viewpoint of personnel selection and placement. Individuals clearly differ in their initial aptitude for making such strategic decisions optimally, but can such differences be adequately overcome by better training? Or do the differences persist irrespective of training? Evidence on these points is at present quite insufficient, and we need to know the answers well before 1980.

(iii) Fault Diagnosis

This will probably become the most important single feature in retraining in the 1980's. Both highly automated manufacturing industries and process industries depend, for maximum productivity, upon the speedy and correct location and rectification of faults - whether they be material faults, system faults or product faults. In recent years fault diagnosis has received an increasing degree of attention from engineers, ergonomists and training specialists. In the service industries, in the military services and in manufacturing industries (especially, e.g. electronics) the diagnostician or "trouble shooter" is recognized as highly important. Much more recently it has been realized that productivity in process industries (e.g. chemical manufacture, oil refining etc.) likewise depends upon the diagnostic ability of the process worker.

We need to give a great deal more attention to this form of mental skill in industry. We all recognize its importance - we have all experienced the chaos which results when the worker "puts right what isn't wrong" and we can all appreciate the enormous cost which is entailed when modern complex plant and equipment lies idle awaiting the identification and rectification of some fault. We have probably all come across the situation where if Arthur is working on a shift, everything seems to go smoothly, but when Bill or Tom's turn comes, stoppages are more frequent and last longer. These are the situations for which, in the 1980's, we shall need adequate retraining. Suffice it to say here that fault diagnosis can be analysed and can be taught but far too few firms or industries have yet tackled this problem with the expertise already available.

(iv) Data Processing Skills

We have all seen at least something of the revolution which has occurred in industrial data processing during the present decade, and we can all recognize that this is going to continue relentessly in the foreseeable future. **Not all of us will** have appreciated the retraining problems which this revolution has presented, is presenting and will present. Changes in the skill profiles of jobs resulting from the use of apparatus in place of man's brain to process industrial data have already been published (e.g. Crossman 1966).

There will be many here much more expert than myself to discuss the problems of training technologists and technicians in this rapidly changing subject, so we will concern outselves here only with the needs of those workers who use the apparatus for data processing. In numerous instances their work appears fairly simple, and workers can be retrained to use such apparatus somehow fairly speedily. But all too frequently the productivity of this costly apparatus depends on the speed skills of operators who feed the information into the apparatus, or prepare that information e.g. punch-card operators. In the future we shall need to give increasing attention to the retraining of workers on tasks of this type. Already Keyboard skills are the subject of research and experiment, and systematic schemes for training such workers already exist. But the provision of such training, and further analyses of the skills required for new apparatus, will occupy an increasingly important part of our training plans for the next decade at least.

(d) New Methods of Communicating the skills content of tasks

Shall we, in the 1980's, have new and better ways of communicating the skills content of tasks? This is clearly an important and an entertaining question. Certain fairly novel methods are already being tried and some of these may well prove advantageous in the future, either by themselves or in conjunction with more traditional means.

Some of you may already have encountered the method of "Mental rehearsal" by which a trainee visualizes the movements etc. to be made in accomplishing a task. After such mental practice the trainee finds that his actual performance is improved. The extent to which such methods can be used in the future will depend upon the nature of job changes, but this is clearly an approach which needs further investigation.

Again synthetic simulations of work situations have already been used for training in industry, as in the military services and service industries. Their design and use requires, however, considerable caution since so many skills in industry are highly specific and it is all too easy to produce simulators which train people for the simulation rather than for the job.

Will it be possible to produce a series of general skill training devices which will pre-train workers for a range of jobs? Shortly before he died my brother Dr. A. H. Seymour was experimenting with such a battery of devices to train workers in iron and steel making plants. As plant and machinery become more complex and less easily available for training purposes, this approach may become essential, but will require much more experimentation before it can be validated.

(e) New Methods of Communicating the knowledge content of tasks

Industry has taken to Programmed Instruction in a big way. Although P. I. is, as one educationalist put it, only what every good teacher has always done, it has provided a discipline for industrial teaching which was sadly lacking in the past.

Within the next decade we can expect it to be used even more but also we may hope that it will be seen in perspective i.e. not just as a panacea for every training problem, but as an essential part of a wider technology of industrial training.

Other more novel methods are known, but have been little used. By 1980, shall we be teaching workers their jobs by "sleep learning"? This, if it occurs, is likely to be part of a wider educational use of new teaching methods, rather than part of exclusively industrial training. The worker found "asleep at his post" may in the future, however, have a novel excuse - that he was learning the next job!

A further and even more fascinating outlook for the future lies in the possibility of improving human learning by the injection of **biochemical substances.** D.N.A. (deoxyribonucleic acid) and R.N.A. (ribonucleic acid) are found in abundance in the nervous system, and the amount of R.N.A. at the synapses increases with neuronal activity. Studies are proceeding to determine the part played by the components of nucleic acid in learning and retention, and it is claimed that, for example, the memories of older people can be improved after injections of R.N.A.

At the moment these ideas are tentative, and verification and replication of experiments, and their extension to industrial situations, are still required. It may, however, be possible in the 1980's to facilitate the learning of new jobs, especially among older workers, by the provision, orally or by injection, of **biochemical substances.**

(f) Towards a Technology of Training

Current developments in training have been aptly epitomised by Wallis (1966) as an emerging "Technology of Training". Already there exist many tools and techniques of training, and by 1980 it may be expected that this technology will be established and recognized.

Training for industrial work involves three major considerations:

First, it must be Analytic, that is to say, it must be based on an analysis and understanding of the skills and knowledge used by the experienced worker in accomplishing the task. Such analysis **constitutes a determination of the terminal behaviour** which is the objective of training.

Second, it must be Systematic, not only (as mentioned in Section 3 above) in presenting learning situations in an organised and not haphazard sequence, but also in providing learning situations of appropriate length, duration and difficulty, with adequate opportunity for repetition and revision. This involves the sub-division of tasks for learning purposes, and the programming of the steps by which they may best be mastered.

Thirdly, it must be Adaptative, in that the means of communication of the skills and knowledge need to be adapted to the existing skills, knowledge and learning capacity of the trainees.

This third requirement is more difficult to meet in the retraining of workers - especially older workers - than it is in the training of young people fresh from school. It has been commonly assumed that such older workers cannot be retrained to perform new tasks; but recent investigations, some of them sponsored by O.E.C.D., have shown that appropriate methods of communicating skills and knowledge to the older retrainees, if they take into account their existing knowledge, expertise and learning capacity, can enable them to master new tasks.

Whatever the age of the retrainees, the objective - the mastery of a new job - will be the same, and hence the skills and knowledge to be acquired are the same. But the starting point and the learning habits of the older worker are different from those of the younger worker, and hence the methods of communicating the skills and knowledge need to be adapted to the needs of the older retrainee.

The researches of Dr. Meredith and Dr. Eunice Belbin have been particularly directed to determining optimum methods for enabling older retrainees to acquire the skills and knowledge required for new tasks. Meredith Belbin's recent O.E.C.D. publication 'The Discovery method - an international experiment in retraining', gives examples from four countries of the results achieved by using these discovery methods in acquiring skills and knowledge. This is yet another technique which can be applied with great advantage in appropriate training situations. Older workers can benefit, not only by mastering new tasks, to their own advantage and that of the community, but also by doing so almost as successfully as younger people.

Thus the training specialist of the future is going to be provided with an increasing number of tools and techniques (or, as Belbin calls them, a battery of training designs) which he can apply, and which constitute his technology of training. The training specialist of 1980 will need, not only to have mastered these techniques, but to be able to determine for which situation each is appropriate. He will need to determine which method of Analysis is best for a given situation - whether Job Analysis, Skills Analysis, Sensori-Motor Process Charts and so on, and to what depth it is appropriate to take the analysis.

Again, he will need to determine what form of systematic training to use - whether by whole methods, part methods, isolation methods - and what size and sequence of training steps to arrange so that the trainee may progress from "can't do and don't know" to "can do and do know" (Seymour, 1968).

Thirdly, he will need to be able to determine the most appropriate means of communicating the skills and knowledge to the retrainees - whether to use, for example, Discovery methods, Programmed Instruction, Visual Aids etc., and in what combination, for different parts of the skills and knowledge to be acquired. Today we are busily discovering and experimenting with new methods of instruction and auto-instruction; by 1980 we shall expect the training specialist to know which of these to use, and when, and where, and how much.

Reference has already been made to the potential use of mass media in industrial training. Here there is a great future possibility, as yet hardly tapped. If television, for example, devoted less time to entertaining us and more time to helping us learn about industrial work and how to do it, we could well benefit economically. But changes of this sort will depend far less upon what employers and trades unions recognize as important, than upon a climate of public opinion which, by 1980 we hope, will have recognized that productive work in the service of others is the most important thing in a healthy, integrated ways of life.

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ADDRESS OF WELCOME BY MR. EMILE BOURSIER,

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It is a great pleasure for me to be with you and it is a great pleasure for my organisation which covers all the metal processing and metal producing industries in France, and that is why I should like to welcome you here to this seminar. I believe we can congratulate O.E.C.D. upon having had a very original initiative and we hope that the results will be favourable; we all of us are interested in this as representatives of trade unions and also as employers. Ten to twelve years is a fairly wide margin but I don't think that we have set our sights too high, and I believe that it should be possible to try and project present trends into the future up to that date.

Our industries are undergoing rapid change: this has been said several times. We try and guess what the consequences of increased automation will be and then the consequences that this will have on the enormous development of production functions or even maintenance functions.

If we keep to the subject of the training of metal workers which is the core of the discussion, I think two sorts of things could be said and these things are very much in the mind of our industry.

The first aspect is the technical changes which our industries are undergoing. I believe that the traditional training will have to be replaced by another sort of training. Our workers are confronted constantly with new processes, and I believe they could be grouped around four main ideas; first, automation, regulation and control - this is one idea. The second idea is new machining processes which are still in their initial stages in some countries but are going to be developed - machining through lasers, electro-static machines etc. Thirdly, the implementation or the application of numerically controlled machine tools for machining, cold forging; and finally the work on special alloys and new materials. I believe that so far most of the training given for these new techniques has been considered as an addition to the basic and former training procedure. I believe that in future this will have to be taken as a specific training per se if we want to meet industry's requirements. This leads me on to the second series of comments which concerns man as such. Today, training is considered as something which has to be taken in toto, as a block, and when one has to take into account a given technical evolution, one has to start almost from scratch, and conversely when a reconversion becomes imperative it is made more difficult by this present procedure of piecemeal training. The new trend of unit training or phased training makes it possible to leave valid certain elements and to add on to them certain new elements in training as and when new and important technological changes take place. We are very interested in knowing how you visualize that this training will be used for the new requirements in industry. I do not wish to go into greater detail of what will be the main pre-occupation now, I merely want to outline to you the thoughts existing at present within the French Employers' Organisation. The subject is of very great interest to us indeed and future training will be a governing factor in the growth rate of the country, and will permit a better adaptation of supply and demand. This adaptation is also a pre-requisite for full employment which is also one of the subjects we both have very much in mind.

Statement by the Trade Union Representative Mr. Charles Ford, Acting General Secretary of the Trade Union Advisory Committee to OECD.

We are all aware that manpower forecasting is in its infancy and that technological forecasting is an even younger technique.

The drawing up of manpower budgets has for long been a trade union demand. (This is increasingly accepted by governments in theory, but insufficiently applied in practice). The need for technological forecasting will also inevitably figure increasingly in trade union programmes.

We shall be discussing both manpower and technological forecasting in the seminar. One cannot make manpower forecasts without seeking to foresee technological developments.

It has been estimated that industry now invests over $65 millions per annum in technological forecasting - of which North America accounts for well over 90 per cent - mainly in large and medium scale industry. 500-600 United States companies have established technological forecasting as an integral part of their operations - which equals about 1 per cent of their total research and development expenditure(1).

It has been estimated that "an efficient technological forecasting function may account for profit gains through new products amounting to as much as 50 times the investment in the "catalytic" forecasting function which triggered R. & D. in the respective areas"(2).

Thus technological forecasting is here to stay, since it pays handsome dividends to the private companies concerned. What would be the social "profit" to be derived from the systematic pursuit of technological forecasting by public authorities?

An especially notable advance is the introduction in recent years of the Planning-Programming-Budgeting System (P.P.B.S.) in the United States civil service and government agencies. This involves the integration of forecasting and planning structures in a framework for decision-making and quantitative five-year planning, tied in with long-range social goals and national objectives.

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(1) "Technological Forecasting in Perspective" - Erich Jantsch, O.E.C.D., 1967, p. 19.

(2) Ibid. p. 20.

Thus the big United States corporations and the government itself are giving great emphasis to providing increasingly vast sums of money for application of interdisciplinary intelligence to foresee "the shape of things to come". European efforts are puny and hesitant in comparison.

The United States attitude is to say: "We know very little about the probable quantitative and qualitative nature of technological change and our present methods are inadequate: we must seek to know more and to forge the technical means for doing so. Therefore, we must improve (however difficult it is to do so) our technical and statistical tools in order to enlarge our knowledge."

The attitude prevailing in many quarters in Europe is rather to say: "Our forecasts have been proved wrong in the past, too many variables are involved, therefore the exercise is not worth carrying out".

This kind of attitude is both a symptom, and a cause of, existing technological gaps which have been defined by O.E.C.D. as educational, managerial and attitudinal. Technological forecasting can be seen as a torch which illuminates the future. If the degree of light is still insufficient, this is no reason to throw the torch away! One must find ways of strengthening the batteries!

Fortunately, there are people in Europe sufficiently imaginative to see the need for technological forecasting; e.g. the Swedish L.O. in its report entitled, "Trade Unions and Technological Change" calls for technological forecasts, "in order to obtain a clearer picture of the places at which changing technology is likely to create employment or adjustment difficulties for workers". Our knowledge is, at present, abysmally inadequate about the consequences of technological change for manpower requirements and hence for training needs.

One of the most compelling facts to emerge from the Grégoire report(1) was the degree to which skilled workers after apprenticeship failed to secure employment in the branch for which they were trained; e.g. **in France** 75 per cent of past **students in certain sections of technical colleges are working in quite a different branch of industry.**

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(1) "Vocational Education, Roger Grégoire, O.E.C.D., 1967.

Young workers having served an apprenticeship in a certain field went into unskilled jobs in the following proportions(1):

Netherlands 43 per cent; United Kingdom 57 per cent; Belgium 70 per cent; Germany 21 per cent.

When astonishment was expressed that in Germany so many metal workers had served their apprenticeship in baking or hairdressing, Roger Grégoire was told they were happy to draw good pay as unskilled workers.

R. Grégoire draws the following conclusions:

1. Training seems to be provided almost everywhere without attention to the needs.
2. Some young people, on completing their training, have to change their trade in order to find work.
3. The rules of the trade preclude their taking skilled jobs even after they have acquired the necessary experience.
4. Trades are demarcated far too strictly either by law or customs.
5. "It may be wondered whether specific training is not a delusion if carried to the extreme".

All this points to an extraordinary waste to the individual concerned as well as to society and the economy. It continues to be a contemporary scandal which should be adequately studied, assessed and the appropriate remedies found as rapidly as possible.

Technological change is likely to accelerate even more in the next decade, inter alia, because of the:

(a) Growing trade liberalization (G.A.T.T., E.E.C., E.F.T.A.), which increases the size of markets and, therefore, makes possible economies of scale;

(b) Growing government participation in the management and financing of industry (R. & D., and increasingly, other investments) which expands capital resources for innovation;

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(1) "Vocational Education", Roger Grégoire, O.E.C.D., 1967.

(c) Growing tendency towards mergers and agreements between companies, inter alia, to take advantage of larger markets and to provide adequate resources for expansion.

Thus we must seek to be just as imaginative as the scientists and technologists by devising policies which will ensure that technological progress does not lead to unmanageable social and economic problems (e.g. traffic congestion, air and water pollution, noise from supersonic aircraft, as well as unemployment and/or shortages of skilled manpower).

One of the aims of our educational system should be to develop imaginative faculties, not only in the natural sciences but also in the social sciences.

Europe needs an educational revolution to parallel the scientific and technological revolution. But at the moment we are too easily satisfied with piecemeal and even puny educational reforms. Ways must be found of mobilizing the teaching profession to help achieve radical changes.

Narrow specialization in education and vocational training is quite inadequate to meet the challenge of change. There is a need to rethink the whole methodology and curricula of primary and secondary education as well as of vocational training. Educational systems in most European countries urgently need modernization and democratization (i.e. better participation of students in higher education bodies and the opening up of educational avenues to children of working-class parents).

Trade unions should give increased prominence in their policies and programmes to educational problems and play an increasing role in promoting educational reforms. Vocational training should be started only after as long as possible a period of secondary education and the length of the training should be adapted to personal capacities. Post-school education should be broadly-based and accompanied by a greatly extended further education. Trainees in industry and commerce, etc., should have the right to release from work for educational purposes.

People are demanding a greater control over their lives in society and in their employment and are dissatisfied with a "conforming society". This implies the need for much greater efforts in the field of adult education, inter alia, to prepare for increased democracy at the work-place.

The whole field of training of adults (for which accelerated technological, economic and social change will create new demands) must be given much greater attention. As the Grégoire Report stated, few systematic studies have been made of what is meant by permanent, life-long education.

The trade unions might examine ways of securing paid educational leave through collective bargaining. (O.E.C.D. should consider reviewing existing practices in the field and make appropriate recommendations). Trade unions should also seek ways of negotiating job enlargement (moving away from narrowly specialized tasks) and of improving the means of securing promotion for workers.

It is vital to ensure that education and training conform more closely both to rising social expectations and the changing needs of the economy. Social and economic needs are not necessarily irreconcilable with one another. Both tend towards the access of more and more young people to a wider and wider cultural, educational and vocational heritage.

Let us hope that this seminar will make a significant contribution to the debate and that it will cause us furiously to think about the cardinal problems involved.

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